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Water Plant Optimization Study

WALPOLE ISLAND WATER TREATMENT PLANT

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WATER PLANT OPTIMIZATION STUDY

Walpole Island
Water Treatment Plant

Project No. 7-2027

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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of the Environment.

WATER PLANT OPTIMIZATION STUDY

WALPOLE ISLAND WATER TREATMENT PLANT

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

The purpose of the Water Plant Optimization Study (WPOS), is to document and review the existing process components and operational procedures and to determine an optimum treatment strategy through an evaluation of particulate removal and disinfection practices.

The optimization study for Walpole Island water treatment plant is part of an ongoing documentation of the operation of the plant. The information in this study would be updated as required.

This study has found that the operation of the water treatment plant at Walpole Island is meeting the objective of producing water that meets the Ontario Drinking Water Objectives on a consistent basis. A summary of recommendations for the improvement of the plant operation are included in the following section.

Physical Improvements:

- additional sampling to be conducted, including monthly sampling for aluminum, benzene, carbon tetrachloride and trihalomethanes;
- a connection of the continuous chart recorder to monitor instantaneous demand;
- connection of the continuous chart recorder for treated water turbidity and an alarm for turbidity levels that exceed the guidelines;
- calibration of both raw and treated water meters and dosage rate of chemical feed pumps;
- sampling of effluent from backwash settling tank;
- monitoring of turbidity following a backwash cycle and consideration of discharging the initial sludge of production to waste;
- operation of plant for longer periods at a lower flow rate during months of low water demand;
- consideration of continuous chemical feed control as part of future expansion of the water treatment plant

Current and projected demand relative to the current plant capacity should be evaluated.

An alternate source of supply such as that proposed in the Lambton-North Kent Area Water Supply Study (1987) will likely be given further consideration in future studies.

INTRODUCTION AND TERMS OF REFERENCE

The Ontario Ministry of the Environment (MOE) has instituted the Water Plant Optimization Study (WPOS), a plant investigation and process evaluation study of water treatment plants in Ontario. The purpose of the WPOS is to document and review present conditions and to determine an optimum treatment strategy for contaminant removal. The WPOS is being conducted in conjunction with the Drinking Water Surveillance Program (DWSP), a continuously updated data base on water quality at Ontario treatment plants.

This study of the Walpole Island Water Treatment Plant has been conducted in accordance with the Terms of Reference prepared by the Ministry of the Environment. A copy of the Terms of Reference are included as Appendix A.

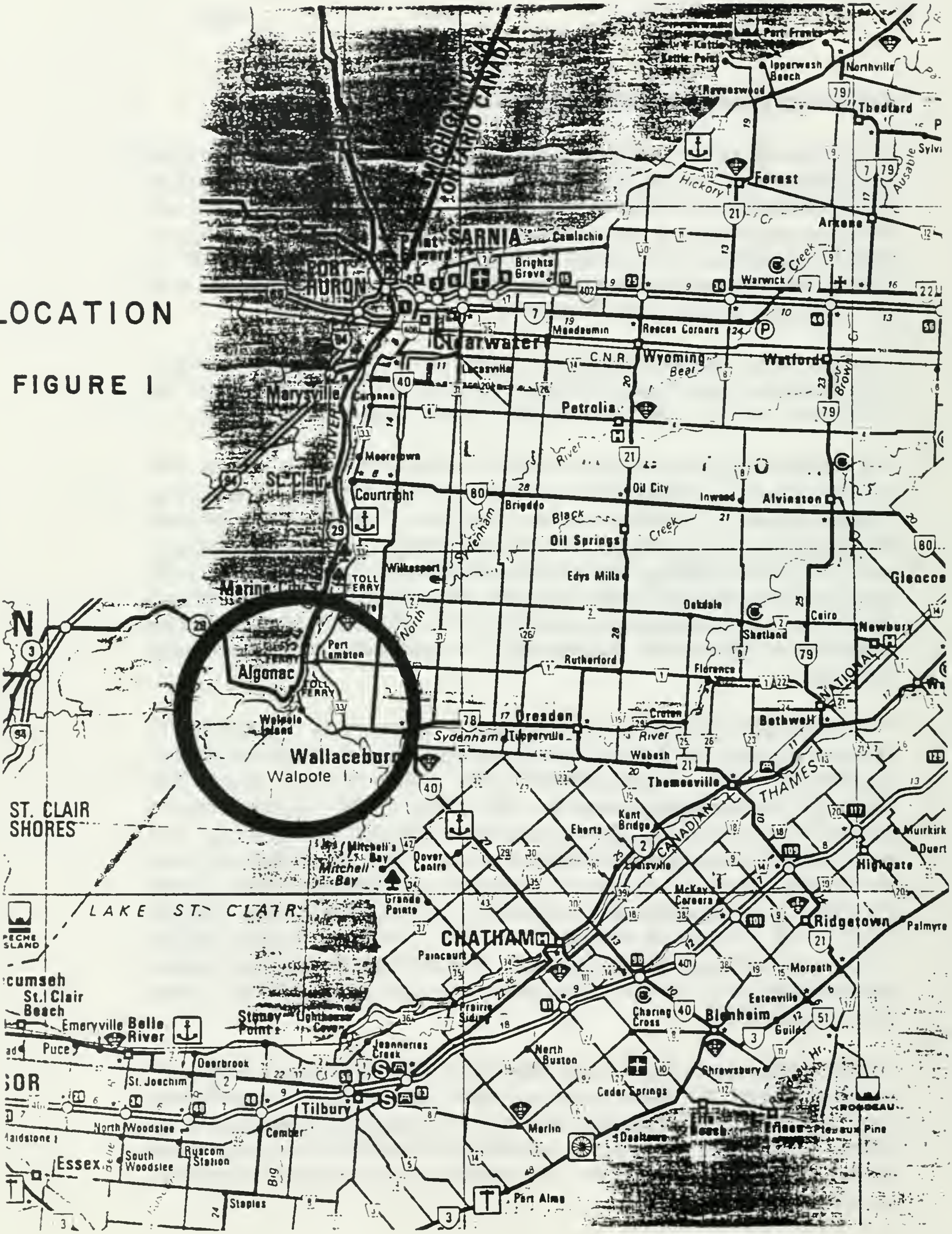
The Walpole Island Indian Reserve is located on the north shore of Lake St. Clair just west of the Town of Wallaceburg and across the St. Clair River from Algonac Michigan (Figure 1). Walpole Island has a population of about 1,790. The water supply system currently supplies 405 residential services, 115 seasonal cottages and 6 community buildings. The serviced population is estimated at about 1,620 permanent residents and about 230 in the seasonal cottages. The Walpole Island water supply system was constructed in 1979-1980 with funding from Indian and Northern Affairs Canada and is currently operated by the Walpole Island Band.

The Walpole Island treatment plant consists of a package plant manufactured by Neptune Microfloc Inc. The treatment process includes chemical feed of alum, polyelectrolyte and powdered activated carbon (PAC), rapid mix, coagulation, flocculation, sedimentation, filtration and disinfection. In 1987, the plant operated at about 37 percent of its design capacity of 959,000 litres per day. The performance of the plant is considered satisfactory. The treated water produced consistently meets the Ministry of the Environment Drinking Water Quality guidelines. Over the period of data collection, the raw water turbidity averaged 7.2 FTU with a maximum reading of 197 FTU. The treated water turbidity averaged 0.21 FTU over the same period. Although there are isolated instances when the objective of 1.0 FTU was exceeded, the maximum treated water turbidity recorded was 2.0 FTU.

This Optimization Study provides a detailed examination of four years of operating data from 1984 to 1987. Water quality and quantity are documented together with a description of the process components and operational procedures at the Walpole Island plant. Through an evaluation of the efficiency of particulate removal and disinfection practices, recommendations are made for optimization of plant performance.

LOCATION

FIGURE I



A. RAW WATER SOURCE

A:1 SOURCE

The Walpole Island water system draws raw water from the St. Clair River at a point located approximately 12 kilometres upstream from Lake St. Clair and about 36 kilometres downstream from the City of Sarnia.

The presence of extensive chemical industrial activity located upstream in the Sarnia area presents a significant potential for chemical spills that impact downstream water users including Walpole Island. The most publicized incident took place in August 1985 when 18 tons of perchloroethylene was discharged into the St. Clair River. Information provided by the Ministry of the Environment indicates that cleanup is ongoing and includes vacuuming of the river bottom. To date, 3.5 tons of chemical have not been recovered. No intakes were reported closed along the St. Clair River. The MOE conducted sampling of raw water quality at Walpole Island and Wallaceburg. The highest concentration sampled, was on August 29, 1985 and indicated a level of 7 ppb of perchoroethylene. The World Health guidelines state 10 ppb as the maximum level acceptance in drinking water.

The following summarizes the outline of the spills response strategy that has been provided by the Southwestern Region of the MOE.

> Under environmental legislation in the Province of Ontario, it is the responsibility of a person or company to notify the Ministry of the Environment immediately following a spill incident. Thus if one of the industries in the Sarnia area spills a pollutant into the St. Clair River, there is sufficient time to evaluate the seriousness of the situation. On average it takes 14 hours for a pollutant spilled in the river at Sarnia to reach the point of intake of the Walpole Island Treatment Plant.
>
> By obtaining the quantity, concentration and nature of the pollutant spilled, the MOE has a model to determine concentrations of the pollutant at the intake of the plant. In this manner, it is possible to determine whether the plant should be shutdown. Even if it is estimated that the pollutant concentrations are below drinking water objectives, the plant is notified by the MOE District Office to increase the dosage of powdered activated carbon and to collect half hour samples for the duration when the pollutant plume is estimated to be passing by the water intake. Samples are sent to the MOE laboratory in Toronto for immediate analysis.

In view of the concerns regarding the water quality of the St. Clair River and the potential for contamination from the chemical activity upstream, Walpole Island

has been added to the communities involved in the Lambton-North Kent Area Water Supply Study. This study is being carried out for the Ministry of the Environment and includes an evaluation of the feasibility of supplying water from Lake Huron to Wallaceburg and Walpole Island.

A:2 GENERAL QUALITY

Water quality data for the period of January 1984 to September 1987 was collected and tabulated in Appendix B. In general, the raw water quality data for the St. Clair River at Walpole Island indicates the following characteristics:

	AVG	MAX	MIN
Turbidity (FTU)	7.2	197	0.6
Colour	5	18	1.5
Temperature (Deg. C)	12	25	0
Alkalinity (mg/L as CaC03)	82	85	80
Hardness (mg/L as CaC03)	99	104	87
pH	8.1	8.3	8.0
Nitrogen (TKN mg/L)	0.2	0.7	0.1
Total Coliform (/100 mL)	2,100	5,900	500
Fecal Coliform (/100 mL)	125	600	19

The raw water supply is generally low in colour and turbidity and could be classified as moderately soft. The operator indicates that turbidity can vary rapidly after a rainfall and strong winds. The potential for chemical spills into the St. Clair River can be regarded as the most significant factor affecting the raw water quality at Walpole Island. To date Ministry sampling of raw water indicates that there were no organic chemicals measured above the concentrations recommended in the Drinking Water Guidelines.

Some concern has been raised on the impact of shipping in the St. Clair River on the raw water quality. The St. Clair River forms part of the St. Lawrence Seaway and the Great Lakes shipping route. The shipping season in this area generally extends from April to December. The maximum speed allowed in the vicinity of Walpole Island is 12 miles per hour and is regulated by the Canadian Coast

Guard. The maximum draw or depth below water of a freighter on the Great Lakes system is 8 m. At the location of the raw water intake, the centre of the river is approximately 10 m deep and the average velocity of the river flow is in the order of 0.7 m/s.

There is a potential for disturbance of the river bottom and deteriorated raw water quality at the intake, especially if ships are travelling at excessive speeds. There is no data to quantify this potential, however, the erosion of the river banks due in part to shipping wakes has resulted in a number of shore erosion projects initiated by the Walpole Island Band.

B. FLOW MEASUREMENT

Both raw and treated water flows are measured by turbine type water meters (Neptune Trident). The raw water meter is located on the 75 mm discharge line from the raw water low lift pumps. The treated water meter is located on the 150 mm discharge header of the high lift pumps.

The water meter information is as follows:

	Raw Water	Treated Water
Meter Size	75 mm	150 mm
Maximum Capacity	27.7 L/s	125 L/s

The water meter readings are recorded daily in the plant log sheet. The mechanism that regulates the post-chlorination feed can also be connected to a continuous strip recorder to record treated water flows, however, this equipment is not currently in use. This data provides an indication of the peak rates of demand.

Discharges from other pumping equipment such as the backwash and water treatment plant effluent pumps are not recorded, however there are elapsed time meters (ETM) on all motor starters and this information may be used to estimate the volumes pumped.

The flow meters are not calibrated on a regular basis. Equipment testing and calibration was last conducted on all metering equipment in 1984.

C. PROCESS COMPONENTS

C:1 GENERAL

The water treatment plant at Walpole Island was completed and commissioned in the spring of 1980. This section describes the major components of the plant. Much of this information is referenced to the Operation and Maintenance Manual prepared for the Walpole Island Band by R. J. Burnside & Associates Ltd. at the time of construction. The components of the water plant are illustrated in the Block Schematic included as Figure 2.

The current operation of the plant is essentially the same as when it was commissioned in 1980. All equipment is original except for the chemical feed equipment for the addition of powdered activated carbon.

C:2 DESIGN DATA

The water supply system was designed based on a combination of Ministry of the Environment and Indian and Northern Affairs Canada (INAC) Technical guidelines. A Certificate of Approval under the Ontario Water Resources Act was not issued as the project was under the jurisdiction of the Federal Department of Indian Affairs, now Indian and Northern Affairs Canada.

The rated capacity of the treatment unit is 0.96 ML/d (11.1 L/s). The actual treatment capacity of the water system is reduced by the quantity of treated water used for backwash. The filters are backwashed on an average of once per day using approximately 30,000 litres of water per cycle. The actual supply capability is therefore 0.93 ML/d.

The average day demand for treated water in 1987 was 0.36 ML/d of 37 percent of the actual plant capacity. The maximum day demand during the period of study occurred in February 1984 at 0.63 ML/d or about 66 percent of the actual plant capacity. However, demand increased significantly during 1988. The average demand was 0.44 ML/d or 47 percent of capacity and the maximum day demand was 0.89 ML/d or 96 percent of the actual plant capacity. On occasion, the plant was operated at full capacity in order to fill the storage reservoir.

The peak rate of water supply that can be delivered to the distribution system is governed by the capacity of the high lift pumping system. If the three high lift pumps operate simultaneously, the combined capacity is 42.2 L/s. Alternatively the diesel driven fire pump can deliver 54.6 L/s. The high lift domestic pumps are locked out when the diesel driven pump is in operation.

The treatment plant building was designed to accommodate a second package plant unit which would effectively double the treatment capacity of the system. A study is currently in progress to update the water supply requirements of Walpole

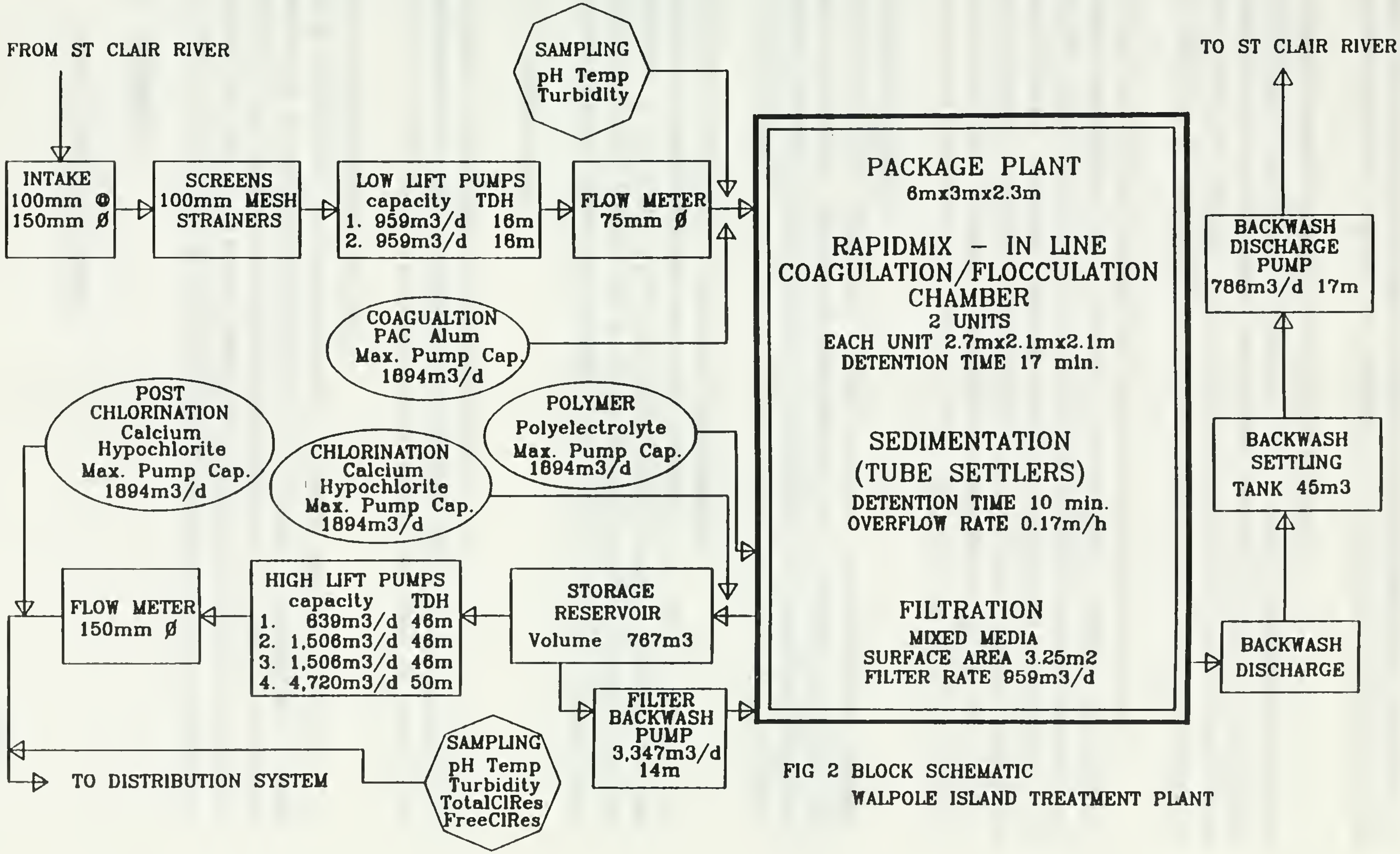


FIG 2 BLOCK SCHEMATIC
WALPOLE ISLAND TREATMENT PLANT

Island. The addition of a second treatment unit will be considered as one of the options to provide additional capacity.

C:3 PROCESS COMPONENT INVENTORY

C:3a INTAKE

The Walpole Island water treatment plant draws water from the St. Clair River through an intake pipe. The 150 mm polyethylene intake line is 200 m long, approximately 40 m of which extends into the river. The intake is anchored in a precast concrete chamber and protected from blockage by a wood screen with 50 mm gaps.

The wood screen was installed to mitigate the potential formation of frazil ice. The intake line was sized for the flow of two Neptune Microfloc treatment units with a combined capacity of 1.9 ML/d (22 L/s). The maximum capacity of the intake is governed by the friction losses that can be tolerated by the low lift or raw water pumps. The limiting factor, in this installation, is the available Net Positive Suction Head (NPSH) required by the raw water pumps. Although the NPSH required depends on the specific pump, assuming a nominal NPSH requirement of approximately 3 m, the capacity of the intake is estimated at 22 L/s (1.9 ML/d).

Provision has been made for back flushing the intake line to the river using the filter backwash pump. The Operation and Maintenance Manual recommends that the intake line be back flushed after the spring thaw, in the fall and whenever blockage is suspected. The operator indicates that the line is backflushed whenever the screens on the raw water pumps are cleaned. This occurs approximately every two to three weeks in the winter and once a month in the summer.

C:3b SCREENING

Strainers are located on the suction line ahead of the raw water pumps and water meter. The purpose of these is to protect the pumps and the water meter. The strainers are made by Sarco and the mesh size of the screen is 3 mm. There are two pressure gauges at the inlet and outlet of each strainer that measure the pressure drop across the strainer to indicate when the screens have accumulated debris and require cleaning. As noted, these screens are cleaned approximately every two to three weeks in the winter and once a month in the summer.

C:3c LOW LIFT PUMPING SYSTEM

The low lift pumping system consists of two horizontally mounted self-priming centrifugal pumps. The pumps are started and stopped automatically by the drop and rise of the water level in the storage reservoir. The start sequence of the two

pumps is alternated to ensure uniform wear of both pumps. Provision has been made for both pumps to operate together. This mode of operation is not normally anticipated as the output of the two pumps exceeds the treatment plant capacity.

RAW WATER PUMP DATA

Quantity	2
Capacity	11.1 L/s (959 m^3/day)
TDH	16 m
Type	self-priming centrifugal
Drive	3.7 kW electric
Manufacturer	Gorman Rupp

C:3d WATER TREATMENT SYSTEM

The Walpole Island treatment plant makes use of a modular pre-engineered treatment system (package plant) manufactured by Neptune Microfloc Inc. The unit is Model AQ-70 and has a nominal flow capacity of 11.1 L/s which is recommended by the manufacturer. The treatment plant was designed to operate with a second treatment unit which could be installed in the future. With the installation of a second module the treatment capacity can be doubled. The dimensions of the package plant tank are 6 m long by 3 m wide by 2.3 m high.

The treatment process includes: chemical feed of alum, polyelectrolyte and powdered activated carbon, rapid mix, coagulation, flocculation, sedimentation, filtration and disinfection.

Powdered activated carbon and alum are injected by feed pumps to the raw water discharge header pipe. The rapid mix of the chemicals is achieved by injecting the PAC and alum into the turbulent flow in the incoming raw water pipeline. The operation of the chemical feed pumps is initiated by the motor starting of the raw water pumps.

The flocculation zone consists of two compartments each with a four paddle mechanical flocculator. Each compartment is approximately 2.7 m by 1.1 m by 2.1 m deep. The wooden paddles are driven by a 1/2 Hp motor. The maximum speed of the motor is 1,750 rpm. The speed is set for 32 percent of the motor speed and reduced further through a gearbox to provide a paddle rotation of 4 rpm. The operator adjusts the paddle speed between 2 and 4 rpm depending on the floc formation. With a detention time of 17 minutes, the Gt value is calculated to be between 60,000 and 120,000 depending on the paddle speed setting.

After the addition of alum and PAC, raw water discharges at atmosphere at the top of the treatment plant into the first flocculation compartment. The initial formation of floc takes place in the first compartment and continues into the second. The water flows under a baffle wall that separates the two flocculation compartments. The total detention time in the flocculation zone is in the order of 17 minutes.

Water flows from the flocculation chamber, over a baffle wall into a distribution chamber, and then out through the bottom into the settling tube clarifier. The flow is directed along the length of the tube settler chamber and is split and directed toward both sides of the tank by the flow vanes in the bottom of the chamber. Half of the flow is then directed up through each of the two stacks of settling tubes. The flow into the tubes is uniformly distributed to all the tube openings by the tapered flow channel formed between the angled face of the tube stack and the tank wall. All of the flow is directed gently, at low velocity, to prevent the breakdown of floc. As the water flows through the tube settlers the floc which has formed settles onto the bottom of the tubes.

The settling tubes are made of polyethylene and the height of each individual tube is approximately 25.4 mm. By passing the flocculated water through the individual tubes, the distance any particle has to fall to contact a settling surface is approximately 25 mm. The actual settling time provided in the tube settlers is approximately ten minutes.

The flow from the settling zone is directed over the regulating weirs from both sides into the trough down the center of the tube settling chamber. The polyelectrolyte filter aid is added here. The trough carries the water to the mixed media filter chamber.

The filter media is the proprietary mixed media supplied by Microfloc. The filter is composed of anthracite, sand and granular materials of varying specific gravity. The following is a description of the material, particle size and corresponding depth of the filter media:

FILTER MEDIA

	Min. Size	Depth
Anthracite	4 mm	0.46 m
Sand	6 mm	0.32 m
Course Gravel	21 mm	0.07 m
Fine Gravel	22 mm	0.07 m
Gravel	5 - 10 mm	0.07 m
Gravel	10 - 20 mm	0.07 m
Gravel	20 - 40 mm	0.23 m

The original filter media supplied by Microfloc is still in use, however, some of the anthracite that is routinely lost has been replaced with material supplied by Anthra Filter.

A centrifugal effluent pump draws water from the filter underdrain to the storage reservoir through a 150 mm diameter line. The pump is necessary as the reservoir level is higher than the filter water level. High groundwater table conditions prevented the construction of a below grade reservoir.

C:3e BACKWASH

As floc particles accumulate in the filter media, the resistance to flow, and therefore the headloss across the filter increases. The backwash cycle is activated when the headloss across the filter exceeds 2.4 m. The backwash uses treated water from the reservoir which is pumped back through the filter media and settling tube clarifier at a rate of 40 L/s. The backwash water is discharged to waste through a 300 mm drain to the underground backwash water settling tank.

Backwash is initiated after a 30 second continuous signal from the level controller in the filter box. The backwash programmer or cam timer, is located in the control panel. Before the backwash starts, the programmer checks that the water level in the storage reservoir is above the intermediate level indicator, to ensure there is sufficient water to run the entire backwash and to ensure that the plant does not go into backwash during an emergency demand condition such as fire. Next the effluent valve closes and the effluent pump and raw water pumps are locked out. The waste valve leading to the backwash settling tank is opened.

The water in the settling tube clarifier drains to flush and scour the floc accumulated on the surface of the tubes to waste. Three minutes after the waste valve opens, the backwash pump starts. The treated water is pumped up through the filter and down the tubes to waste.

When the backwash is complete, the waste valve closes and the backwash pump continues to run for approximately 3 minutes to refill the tube clarifier to ready the plant for normal operation. The complete backwash cycle takes in the order of 11 to 12 minutes to complete.

The level controller in the filter box has two emergency features. If the water level should fall, for example because of a problem with the raw waste supply or the waste valve left open, the low level limit switch will close the effluent valve and pump. If, during the backwash, the water level in the tank approaches the point where there is a potential for an overflow, (approximately 12 mm from the top), the backwash pump will be locked out.

Conditions such as low and high levels are communicated by an alarm to advise the operator so that corrective action can be taken.

C:3f BACKWASH WATER SETTLING TANK

The backwash water settling tank is of precast concrete construction measuring 2.4 x 2.7 x 7.0 m inside with a total capacity of 45,460 litres. The tank is located below grade at the south side of the treatment plant facility.

A submersible pump is located about 1 m above the bottom of the tank. The suspension in the backwash discharge and accumulated sludge are allowed to settle for one hour. After settling the supernatant water is decanted by the submersible pump through a 75 mm discharge line to the St. Clair River. The practice of discharging backwash water to a watercourse normally requires a Certificate of Approval from the Ministry of the Environment. Sedimentation is the normally accepted method for treating the backwash discharge. The quality of the decant has not been determined and it may be appropriate to sample the effluent from the backwash settling tank before discharge.

When sludge accumulates over a depth of 0.6 m, the tank is cleaned with a pumper truck. The sludge is disposed of at the local landfill site operated by the Walpole Island Band.

TREATMENT PLANT PUMP DATA

	Effluent	Filter Backwash	Backwash Discharge
Quantity	1	1	1
Capacity	11.1 L/s	40 L/s	9.1 L/s
TDH	45.7 m	13.7 m	17.4 m
Type	end suction centrifugal	end suction centrifugal	submersible
Drive	5.6 kW	7.5 kW	1.2 kW
Manufacturer	Peerless	Peerless	Flygt

C:3g STORAGE RESERVOIR

The reservoir is of poured in place reinforced concrete construction and provides 787 m^3 of storage. The reservoir is located at the back or the east side of the treatment plant building. The reservoir is comprised of two cells of equal capacity inter-connected by a 300 mm diameter pipe. Each cell can be taken out of service for maintenance by closing a valve on the inter-connecting pipe.

C:3h DOMESTIC HIGH LIFT PUMPS

There are four vertical lineshaft turbine, high lift pumps to draw water from the storage reservoir and into the distribution system.

Pump No. 1 is rated at a capacity of 7.4 L/s and starts when the pressure in the distribution system drops to 310 kPa (45 psi). The No. 1 pump is stopped when the water level in the hydropneumatic tank reaches the stop level probe. The level corresponds to a system pressure of 480 kPa (70 psi).

Pump No. 2 is rated at a capacity of 17.4 L/s and starts if the pressure in the system drops to 275 kPa (40 psi). This occurs when the demand or if is greater than the capacity of Pump No. 1 or when Pump No. 1 is out of operation.

Pump No. 3 is also rated at a capacity of 17.4 L/s and starts if the pressure in the system drops to 240 kPa (35 psi). This will occur when Pump No. 1 and 2 cannot supply the demand or if one of these units is out of operation. Pumps No. 2 and 3 stop when the pressure in the system is restored to 450 kPa (65 psi).

The fourth pump, a diesel driven pump is started automatically when the system pressure reaches 210 kPa (30 psi). This unit operates in the event of low system pressures which are apt to occur during excessive demand or prolonged power outage.

HIGH LIFT PUMP DATA

Pump No.	1	2	3	4
Capacity	7.4 L/s	17.4 L/s	17.4 L/s	54.6 L/s
TDH	45.7 m	45.7 m	45.7 m	65.0 m
Start	310 kPa	275 kPa	240 kPa	210 kPa
Stop	480 kPa	450 kPa	450 kPa	manual
Power	5.6 kW	11.2 kW	11.2 kW	67.1 kW Diesel
Manufacturer	Fairbanks Morse	Fairbanks Morse	Fairbanks Morse	Fairbanks Morse

C.4 CHEMICAL SYSTEMS

Chemicals are added in several locations throughout the treatment process. Alum is added to the raw water as a flocculating agent at the 150 mm header pipe leading from the raw water pumps into the treatment plant. Rapid mixture is provided by turbulent flow in the raw water pipe and by discharge to atmosphere at the top of the plant in the first flocculation chamber. Activated carbon was first added in January of 1986 after the perchloroethylene spill of August 1985. The carbon feed point is located immediately before the alum feed. Polyelectrolyte is added prior to the filtration process.

Originally, chlorine was added to the raw water on the discharge line to the treatment plant. Due to concerns that the chlorine would combine with organics in the raw water and form compounds such as trihalomethanes (THM), the point of injection was relocated and chlorine is now added to the treated water after filtration.

Post chlorination occurs after pumping from the reservoir and before the water enters the distribution system. Powdered calcium hypochlorite is used as the chlorine source for both pre and post chlorination. The following is a description of each of the chemicals used

Chemical	Application Point	Supplier	Brand	State
Alum	150 mm raw water line	Harrison & Crossfield	Alcan	ground
PAC	150 mm raw water line	Van Waters	Sternson	powdered
Polyelectrolyte	trough before filtration	Alchem	8170 polymer	pulverized
Pre-Chlorination	after filtration	Harrison & Crossfield	65% HCH	powdered
Post-Chlorination	high lift leader before distribution	Harrison & Crossfield	65% HCH	powdered

The chemicals are stored in powdered form in 40 kg bags, stacked on pallets inside the treatment plant building. When required, the chemicals are mixed to the proper concentrations in the solution storage tanks. The storage tanks are made of fiberglass with PVC covers manufactured by Chemtrol. The alum storage tank has a capacity of 1500 litres (400 US gal) and each of the other chemicals are mixed in 380 litre (100 US gal) tanks. The alum, PAC and polyelectrolyte tanks are located at the raw water side of the package plant near the flocculation chamber. The chlorine tanks are located on the filter side of the treatment plant near the high lift pumps. The floor plan Figure 3 shows the location of the chemical feeders and storage tanks.

Each tank is provided with a Lightnin electric mixer driven by a 1/4 Hp motor.

The chemical solutions are injected into the water supply at closely regulated rates with metering pumps. The feed pumps are manufactured by Wallace and Tiernan (Model #44-747) and have a maximum capacity of 1900 L/day.

The capacity of the feed pumps is adjustable by varying the pump speed and the length of the stroke of the piston.

The pumps start and stop with the low lift (raw water) pumps through the motor starters mounted on the westerly wall of the treatment plant building. The polyelectrolyte pump, also stops when the backwash programmer engages. The post chlorination is regulated by proportional flow through the treated water meter.

C:5 SAMPLING

There is a sampling tap located on the raw water discharge after the raw water meter and on the high lift discharge before the distribution system. The

operator samples both raw and treated water for testing which may be conducted in the plant office or sent away to the MOE or private laboratory.

C:6 STANDBY POWER

Some emergency power is provided by the diesel driven fire pump. The pump has a rated capacity of 55 L/s at a TDH of 65 m. The pump is a 3-stage vertical lineshaft can type, Model #12L, Fig. 7000 manufacturered by Fairbanks Morse. The diesel pump provides additional pumping capacity for situations which require large quantities of water such as fire fighting. The diesel will also run during a power failure to maintain water pressure in the distribution system. There is a small generator driven by the same diesel engine which provides some electrical power to the essential services within the building such as the heating system, emergency lights, motorized louvers and post chlorination equipment.

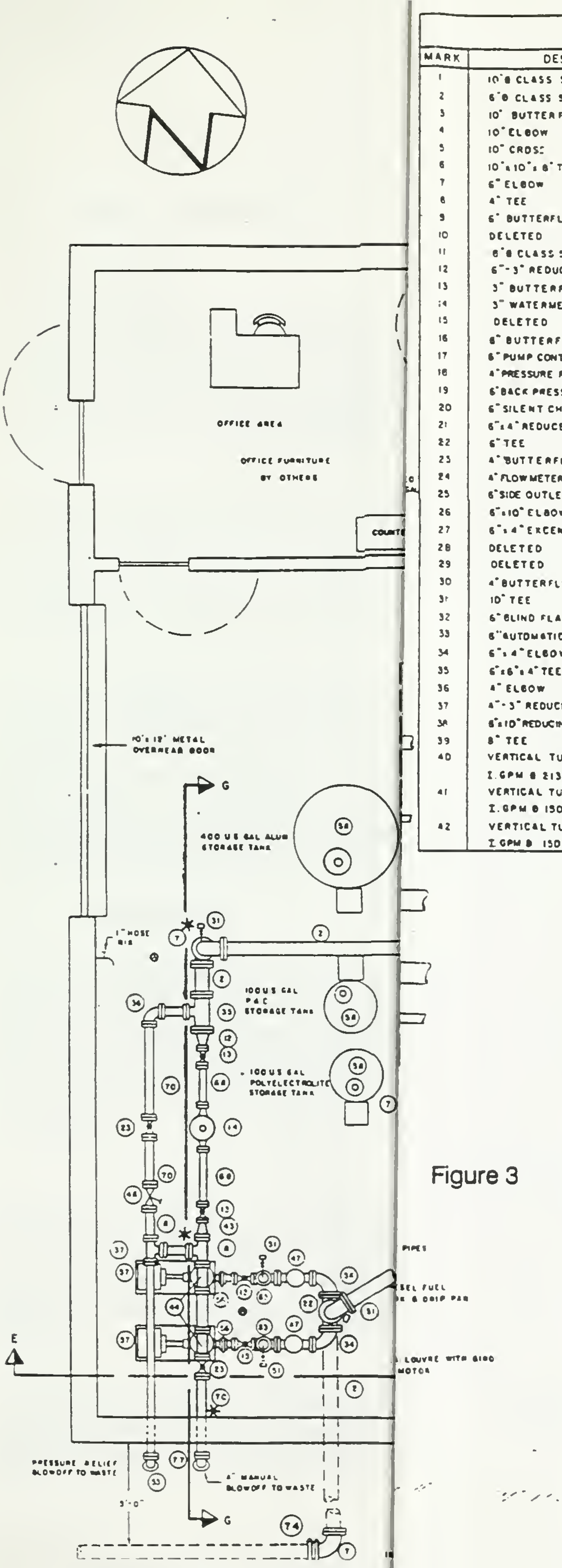
There is no production of treated water during a power failure since the raw water pumps and corresponding chemical feed equipment are not supplied with power. Treated water stored in the reservoir is used for distribution by the diesel fire pump.

The diesel engine starts automatically if the pressure in the distribution system drops to 210 kPa (30 psi) as in a fire situation. The diesel engine must be shut down manually when the emergency is over. The engine will also start automatically in the event of a normal power failure, but it will shut down automatically when normal power is restored. The diesel engine manufacturer is Harper-Detroit Diesel. The engine is presently tested on a weekly basis.

C:7 DRAWINGS

A Block Schematic of the treatment plant was included as Figure 2. Figure 3 shows the floor plan of the building.

Photographs of the various components of the treatment system are included as Appendix C.



PARTS LIST			Page 18
MARK	DESCRIPTION	MARK	DESCRIPTION
1	10" Ø CLASS 52 D.I. PIPE	43	3"-4" REDUCER
2	6" Ø CLASS 52 DI PIPE	44	4"x4"x3" TEE
3	10" BUTTERFLY VALVE	45	4"x4"x6" TEE
4	10" ELBOW	46	3" PRESSURE RELIEF VALVE
5	10" CROSS	47	4" STRAINER
6	10"x10"x8" TEE	48	6" CROSS
7	6" ELBOW	49	8"x6" REDUCER
8	4" TEE	50	10"x8" REDUCER
9	6" BUTTERFLY VALVE	51	VACUUM GAUGE ISOLATED BY
10	DELETED		GLOBE VALVE
11	8" Ø CLASS 52 DI PIPE	52	DELETED
12	6"-3" REDUCER	53	3"-45° ELBOW
13	3" BUTTERFLY VALVE	54	3" ELBOW
14	3" WATERMETER	55	3" SILENT CHECK VALVE
15	DELETED	56	3" UNION
16	6" BUTTERFLY VALVE	57	SELF PRIMING CENTRIFUGAL RAW
17	6" PUMP CONTROL VALVE (FLG)		WATER SUPPLY PUMP 150 I GPM @
18	4" PRESSURE RELIEF VALVE (FLG)		73 FT TDH (WITH MOTOR & BASE)
19	6" BACK PRESSURE CHECK VALVE (FLG)	58	CHEMICAL STORAGE TANK WITH
20	6" SILENT CHECK VALVE		MIXER & FEED PUMPS
21	6"x4" REDUCER	59	DELETED
22	6" TEE	60	DIESEL ENGINE - FUEL TANK & HEAT
23	4" BUTTERFLY VALVE		EXCHANGER
24	4" FLOWMETER WITH IMPULSE SWITCH	61	PACKAGE WATER TREATMENT PLANT
25	6" SIDE OUTLET ELBOW		150 I GPM CAPACITY
26	6"x10" ELBOW (FLG)	62	DOMESTIC COLUMN SUMP
27	6"x4" EXCENTRIC REDUCER		PUMP 1/3 HP
28	DELETED	63	4"x3"x4" TEE
29	DELETED	64	TREATMENT PLANT & RAW WATER
30	4" BUTTERFLY VALVE		INTAKE BACKWASH PUMP
31	10" TEE	65	TREATMENT PLANT EFFLUENT PUMP
32	6" BLIND FLANGE	66	4" CHECK VALVE
33	6" AUTOMATIC BACKWASH VALVE	67	STANDPIPE FOR RESERVOIR LEVEL
34	6"x4" ELBOW		CONTROLS
35	6"x6"x4" TEE	68	4" VICTAULIC COUPLING
36	4" ELBOW	69	3" Ø CLASS 52 DI PIPE
37	4"-3" REDUCING COMPANION FLANGE	70	4" Ø CLASS 52 DI PIPE
38	8"x10" REDUCING COMPANION FLANGE	71	6" 45° ELBOW
39	8" TEE	72	DELETED
40	VERTICAL TURBINE CAN PUMP 720	73	DELETED
	I.GPM @ 213' TDH	74	DI PE FLANGED ADAPTER
41	VERTICAL TURBINE CAN PUMP 230	75	10" MJ ELBOW
	I.GPM @ 150' TDH	76	10" BUTTERFLY (AUTOMATIC)
42	VERTICAL TURBINE CAN PUMP 96	77	4"-45° ELBOW
	I GPM @ 150' TDH	78	4"x3" ELBOW

SCHEDULE OF REVISIONS			
NO.	DATE	DESCRIPTION	CHECKED
1	MAY 1981	REVISED AS CONSTRUCTED	

Figure 3

R. J. BURNSIDE P. ENG. — J. M. TURPING P. ENG.

PUMPHOUSE
FLOOR PLAN

WALPOLE ISLAND INDIAN RESERVE

DRAWN: D. C. MONTGOMERY	DRAWING NO. C-320-4
APPROVED: R. J. BURNSIDE	SCALE 3/8" = 1'-0"
DATE: APRIL 1978	ISSUED

CLIENT
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

R. J. BURNSIDE & ASSOCIATES LTD.
CONSULTING MUNICIPAL ENGINEERS
30 MILL STREET, ORANGEVILLE, ONTARIO

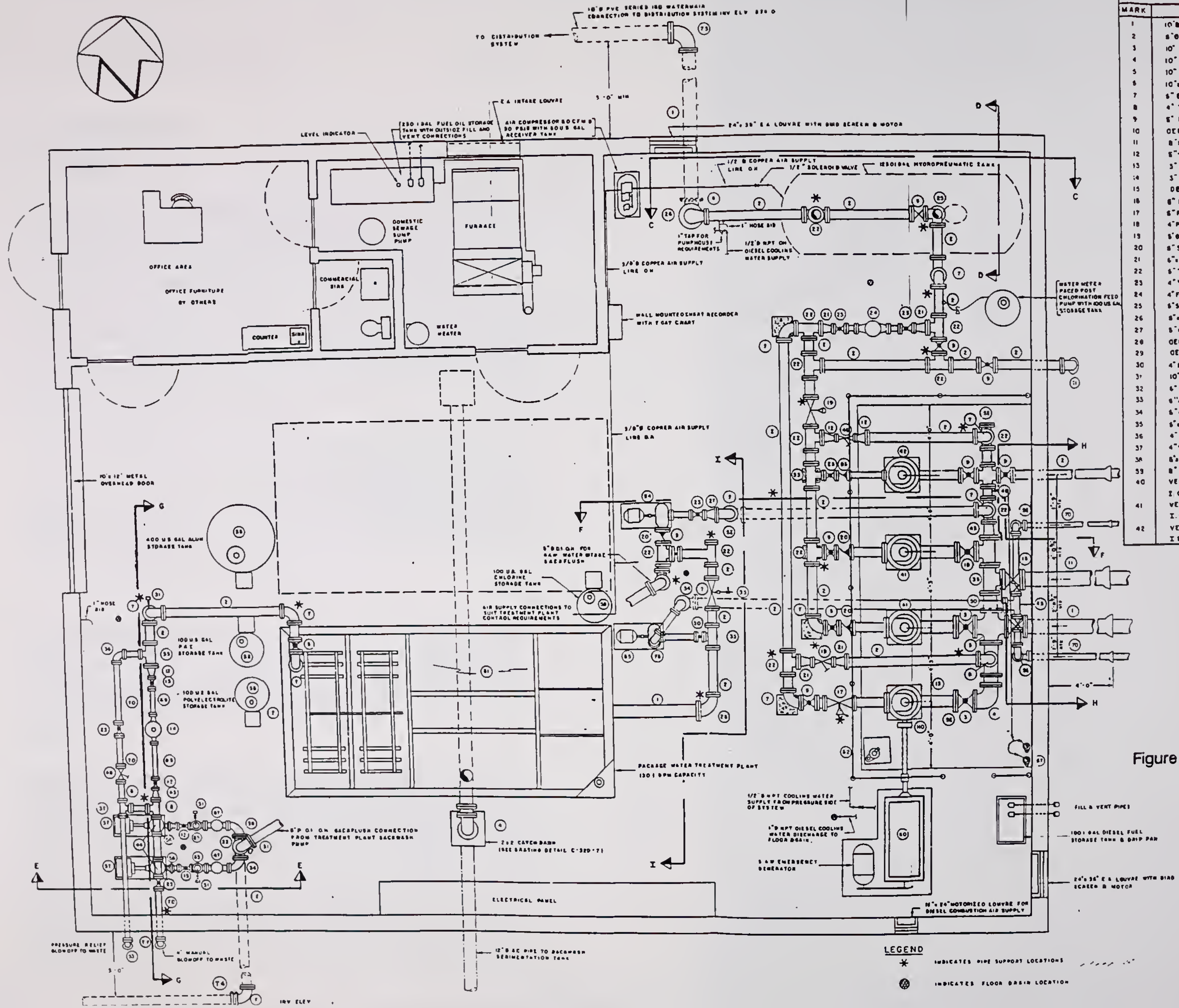


Figure 3

PARTS LIST

MARK	DESCRIPTION	MARK	DESCRIPTION
1	10"Ø CLASS 52 DI PIPE	43	3"-4" REDUCER
2	8"Ø CLASS 52 DI PIPE	44	4"x4"x3" TEE
3	10" BUTTERFLY VALVE	45	4"x4"x6" TEE
4	10" ELBOW	46	3" PRESSURE RELIEF VALVE
5	10" CROSS	47	4" STRAINER
6	10"x10"x8" TEE	48	8" CROSS
7	6" ELBOW	49	8"x6" REDUCER
8	4" TEE	50	10"x8" REDUCER
9	8" BUTTERFLY VALVE	51	VACUUM GAUGE ISOLATED BY
10	DELETED		GLOBE VALVE
11	8"Ø CLASS 52 DI PIPE	52	DELETED
12	8"-3" REDUCER	53	3"-45° ELBOW
13	3" BUTTERFLY VALVE	54	3" ELBOW
14	3" WATERMETER	55	3" SILENT CHECK VALVE
15	DELETED	56	3" UNION
16	6" BUTTERFLY VALVE	57	SELF PRIMING CENTRIFUGAL RAW
17	6" PUMP CONTROL VALVE (FLG)		WATER SUPPLY PUMP 150 I GPM @
18	4" PRESSURE RELIEF VALVE (FLG)		73 FT TDH (WITH MOTOR & BASE
19	6" BACK PRESSURE CHECK VALVE(FLG)	58	CHEMICAL STORAGE TANK WITH
20	8" SILENT CHECK VALVE		MIXER & FEED PUMPS
21	6"x4" REDUCER	59	DELETED
22	6" TEE	60	DIESEL ENGINE-FUEL TANK & HEAT
23	4" BUTTERFLY VALVE		EXCHANGER
24	4" FLOW METER WITH IMPULSE SWITCH	61	PACKAGE WATER TREATMENT PLA
25	6" SIDE OUTLET ELBOW		150 I GPM CAPACITY
26	8"x10" ELBOW (FLG)	62	DOMESTIC COLUMN SUMP
27	6"x4" EXCENTRIC REDUCER		PUMP 1/3 HP
28	DELETED	63	4"x3"x4" TEE
29	DELETED	64	TREATMENT PLANT & RAW WATER
30	4" BUTTERFLY VALVE		INTAKE BACKWASH PUMP
31	10" TEE	65	TREATMENT PLANT EFFLUENT PUMP
32	6" BLIND FLANGE	66	4" CHECK VALVE
33	8" AUTOMATIC BACKWASH VALVE	67	STANDPIPE FOR RESERVOIR LEVEL
34	6"x4" ELBOW		CONTROLS
35	6"x8"x4" TEE	68	4" VICTAULIC COUPLING
36	4" ELBOW	69	3"Ø CLASS 52 DI PIPE
37	4"-3" REDUCING COMPANION FLANGE	70	4"Ø CLASS 52 DI PIPE
38	6"x10" REDUCING COMPANION FLANGE	71	6" 45° ELBOW
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42	VERTICAL TURBINE CAN PUMP 98	77	4"-45° ELBOW
	I GPM @ 150' TDH	78	4"x3" ELBOW

SCHEDULE OF REVISIONS

NO.	DATE	DESCRIPTION	CHECKED
1	MAY 1981	REVISED AS CONSTRUCTED	[illegible]

R. J. BURNSIDE P. ENG

J. M. TUPLING P. ENG

PUMPHOUSE

FLOOR PLAN

WALPOLE ISLAND INDIAN RESERVE

DRAWN: D C MONTGOMERY	DRAWING NO. C-320-4
APPROVED: R. J. BURNSIDE	SCALE: 3/8" = 1'-0"
DATE: APRIL 1976	ISSUED

CLIENT: DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

R.J. BURNSIDE & ASSOCIATES LTD.
CONSULTING MUNICIPAL ENGINEERS
30 MILL STREET ORANGEVILLE ONTARIO

D. PLANT OPERATION

D:1 GENERAL

The water treatment plant operates on an ON-OFF basis controlled by the water level in the storage reservoir. When the water level drops below the specified level the raw water pumps are signaled to start pumping water through the package plant. The plant operates in a conventional manner and includes rapid mix, coagulation, flocculation, sedimentation, filtration and disinfection.

The Walpole Island water treatment plant is operated by the Walpole Island Band by two operators. Both operators have other duties within the Public Works Department in addition to the operation of the water treatment plant. The plant is manned for at least 4 hours per day including weekends. Alarm conditions are signaled by a red light outside of the building and this situation is relayed to one of the operators when the plant is not manned.

On a daily basis, the operator records the quantity of water being treated and pumped to the distribution system, the temperature, turbidity and pH of both raw and treated water, the chlorine residual and the chemical feed rates. The plant operator also records the hours of operation of the diesel driven fire pump on a regular basis. This information is recorded on the plant operation log sheet. An example of the log sheet is included as Appendix F. A more detailed description of sampling procedures will be included later in the report.

D:2 FLOW CONTROL

The plant is designed to run in automatic mode on an ON-OFF basis. The raw water pumps are signaled to start by the water level in the storage reservoir. When on the plant operates at a consistent rate of 11.1 L/s. The start sequence of the two raw water pumps is alternated to ensure uniform wear of both pumps. Provision has been made for both pumps to operate together, however this mode of operation is not anticipated unless the capacity of the treatment plant is expanded.

The rate of flow through the package treatment plant, including sedimentation and filtration is held constant at 11.1 L/s. As headloss increases across the filter bed, as sensed by the level controller, the effluent valve opens gradually to compensate and maintain a constant flow rate across the filter. When the pressure exceeds the predetermined headloss of 2.4 m the backwash cycle is initiated.

The operation of the high lift pumps is controlled by pressure in the distribution system through a hydropneumatic tank. The lead pump, the smallest of the three high lift pumps starts when the pressure in the distribution system drops below 310 kPa (45 psi).

D:3 DISINFECTION PRACTICES

Disinfection at the Walpole Island treatment plant is achieved by chlorination. The chemical used is calcium hypochlorite containing 65 percent active chlorine. The prechlorination feed was originally located in the raw water line to the package plant. Due to concerns with the formation of trihalomethanes, the feed point has been moved to the line leading from the filtration unit to the storage reservoir. The post-chlorination feed is located on the header pipe for the high lift pumps leading to the distribution system.

Prior to 1986, the feed rate for chlorination was not recorded, however the amount of chemical by weight was recorded when a new batch of solution was mixed. Beginning in 1986, both the amount of chemical added and the feed rate were recorded.

The dosage is determined by the operator by monitoring the total residual. The feed pump stroke and frequency is adjusted to achieve the desired dosage, according to the capacity curves provided by the manufacturer. Examples of these curves are included in Appendix D.

The operator has determined that the dosages recorded in the plant log did not correspond to the amount of chemical added. The operator revealed that there were problems with the metering pump. Some internal parts were slipping and required replacement. Because it is not possible to determine when the problems began and because of the conflicting data, the feed rates recorded in the log are not considered reliable for either pre or post-chlorination. For this study, a monthly average feed rate has been determined. This is calculated by the total weight of chemical added adjusted for the percentage of active ingredient, divided by the total quantity of water pumped. The volume of raw water is used for chlorination dosages and treated water pumped for post-chlorination dosages. This average feed rate is approximate and does not account for the amount of solution stored in the tank at the beginning and end of the month.

The average pre-chlorination feed rates range from 1.0 mg/L to 2.0 mg/L with an average during the period of observation of 1.4 mg/L. The average feed rates for post-chlorination range from 0.03 mg/L to 0.4 mg/L with an average of 0.1 mg/L. These values for post-chlorination appear low although the average for 1987 increased to 0.2 mg/L. It is of interest to note that the dosages recorded by the operator range from 0.25 to 36 mg/L for the same period. This indicates that the operator may not have been aware of the inaccuracy of the dosages as recorded.

The operator sets the feed rate in response to the chlorine residual measured. In general, a seasonal variation is observed with the highest chlorine dosages occurring in early spring and again in late fall. This trend is more pronounced with the pre-chlorination dosages than the post-chlorination dosages.

D:4 OPERATION OF SPECIFIC COMPONENTS

D:4a INTAKE

The intake consists of a 150 mm polyethylene line extending into the St. Clair River. Both the intake crib structure and the pipe line were designed with minimal use of metal parts to avoid problems with frazil ice. Problems with frazil ice were common on an old intake that preceded the current system. Backflushing occurs whenever the screens on the raw water pumps are cleaned, approximately once a month. There is no schedule for manual inspection of the intake. An inspection is completed only in response to the indication of a problem.

D:4b LOW LIFT PUMPS

The low lift or raw water pumps consist of two horizontally mounted self priming centrifugal pumps. The pumps are controlled automatically by the level in the reservoir and pump at a constant rate of 11.1 L/s. The start sequence is alternated to ensure uniform wear of both pumps. Provision has been made for both pumps to operate together, however, this is not necessary unless the treatment plant is expanded.

D:4c PACKAGE TREATMENT PLANT

The Neptune Microfloc package treatment plant operates at a constant flow of 11.1 L/s, the design flow rate for the plant. Given the constant flow rate the greatest flexibility available to the operation is the adjustment of the chemical dosage. This is largely set by the operator in response to jar test results and will be discussed in detail in a subsequent section of this report.

Another alternative available to the operator is to adjust the frequency of backwash. The backwash is activated automatically when the headloss measured across the filter exceeds 2.4 m, but can also be activated manually by the operator. The backwash cycle is described in detail in the section C:3 - Process Component Inventory.

D:4d STORAGE RESERVOIR

Storage of 787 cu.m. is provided by the concrete grade level reservoir. The water is chlorinated before entering the storage reservoir.

The reservoir consists of two compartments connected by a 300 mm diameter pipe. Either of the cells can be taken out of service for cleaning by closing the valve on the connecting pipe. The raw water pumps can be activated manually to fill the reservoir if the operator has advance knowledge of a plant shut down due to plant maintenance or a chemical spill in the St. Clair River.

D:5 CHEMICALS

The dosage of alum and polyelectrolyte are determined using the results from jar testing. The jar tests are carried out following the procedure outlined by the MOE in the Basic Water Treatment Operation Manual. An outline of the procedure along with an example of jar testing results is included as Appendix E. Jar testing is completed once daily. If the turbidity level of the raw water is elevated and changing rapidly, the operator conducts jar tests on an hourly basis until the chemical feed is adjusted correctly and the water quality stabilizes.

The chemicals are stored in powdered form and mixed in solution as required in the mixing tanks. The selected dosage is applied with chemical metering pumps. The pumps are not calibrated regularly.

The pump stroke is adjusted manually to achieve the required dosage, according to the dosage curves supplied by the manufacturer. Examples of the dosage curves are included in Appendix D.

The operator will change the dosage in response to changing turbidity levels. The operator anticipates rising turbidity levels after storms and based on previous operational experience adjusts the chemical feed accordingly.

D:6 SAMPLING AND DATA COLLECTION

A summary of the sampling and data collection information is tabulated on the following page. In addition to the testing equipment listed, the operator has recently acquired a Hach DR/3 Spectrophotometer, Model No. 4200. Each of the parameters are recorded by the operator daily on the monthly log sheet. The information is customarily recorded between 7 and 8 a.m. in the morning; the time of recording is noted on the log sheet. The completed log sheets are retained in the plant office. To date, no systematic analysis of the recorded data is conducted.

The Neptune Microfloc plant comes equipped with a continuous strip chart recorder, Bristol 4621 to measure and record turbidity and a DPD Free Chlorine Analyzer, Hach 16700. Both of these units are mounted on the end of the treatment plant tank outside the filtration chamber and were installed to measure filtered water before it is pumped to the storage reservoir. Neither of these instruments are currently in use, rather, the treated water turbidity and chlorine residual are determined from samples taken from the high lift header pipe before the distribution system.

Bacteriological testing is completed by the operator once monthly and sent to the Lambton County Health Unit for analysis. Samples are taken of raw water and treated water at the plant and at several different points of use.

DATA COLLECTION SUMMARY

Parameter	Location	Recording Frequency	Measuring Instrument
Raw water metering	75 mm dia. line low lift pump discharge	once daily	Neptune Trident turbine type meter
Treated Water metering	150 mm dia. line high lift header	once daily	Neptune Trident turbine type meter
Chemical Feed Rates		- once daily for dosage - as required for number of bags added.	

SAMPLING SUMMARY

Parameter	Sampling Point	Testing Frequency	Testing Instrument
<u>**Raw Water**</u>			
Turbidity	75 mm dia. line following raw water meter	once daily	Hach Ratio Turbidimeter No. 18900
Temperature	75 mm dia. line following raw water meter	once daily	thermometer
pH	75 mm dia. line following raw water meter	once daily	probe type meter
<u>**Treated Water**</u>			
Turbidity	high lift header to distribution system	once daily	Hach Ratio Turbidimeter No. 18900
Temperature	high lift header to distribution system	once daily	thermometer
pH	high lift header to distribution system	once daily	probe type meter
Total Chlorine Residual	high lift header to distribution system	once daily	hand held Hach kit
Free Chlorine Residual	high lift header to distribution system	once daily	hand held Hach kit

E. EVALUATION OF PLANT PERFORMANCE

E:1 GENERAL

The evaluation of the performance of the water treatment plant at Walpole Island is based on the operational data collected from the plant log as maintained by the operator and from the data collected by the Ministry of the Environment.

E:2 TURBIDITY

The review of the data period indicates that the raw water turbidity averaged in the order of 7.2 FTU. The treated water turbidity averaged 0.21 FTU over the same period of time. The turbidity results are presented in Figures 4 and 5 to illustrate the pattern of turbidity levels in a graphic format. The raw water turbidity peaks in spring and fall where as the peaks in the treated water are more sporadic.

The maximum turbidity measured in the raw water was 197 FTU on April 5, 1987. On the subsequent days, April 6, 7, 8, 9 and 10, the raw water turbidity was measured at 88, 60, 20, 17, and 9.6 FTU. The corresponding raw water temperature was measured at 3.5 °C. Over the same period of time the treated water turbidity was measured at 0.13, 0.19, 0.20, 0.19, 0.21 and 0.18 FTU.

The highest treated water turbidity measured was 2.1 FTU on February 11, 1986. The corresponding raw water turbidity was measured at 8.1 FTU. On the day before and day after the treated water turbidity was 0.8 FTU and less than the detection limit respectively. The raw water turbidity on the day before and day after was 6.1 and 1.8 FTU respectively.

There are 21 days during the period of data where the treated water turbidity exceeded the Drinking Water Objectives. These incidents are listed in Table 7.0 Exceedance Summary.

Although the maximum acceptable concentration listed in the Ontario Drinking Water Objectives is 1.0 FTU, the objective is to achieve as low a value of treated water turbidity as technologically possible.

A review of the operational records indicate that the chemical dosages generally fall in the following range:

Raw Water Turbidity	Raw Water Temp.	Alum Dosage	Poly Dosage	Treated Water Turbidity
197 FTU	3° C	40 mg/L	0.88 mg/L	0.2 FTU
80 FTU	3° C	20 mg/L	0.45 mg/L	0.2 FTU
25 FTU	1° C	30 mg/L	0.45 mg/L	0.2 FTU
10 FTU	10°C	10 mg/L	0.22 mg/L	0.2 FTU
5 FTU	1°C	12 mg/L	0.4 mg/L	0.1 FTU

Figure 4

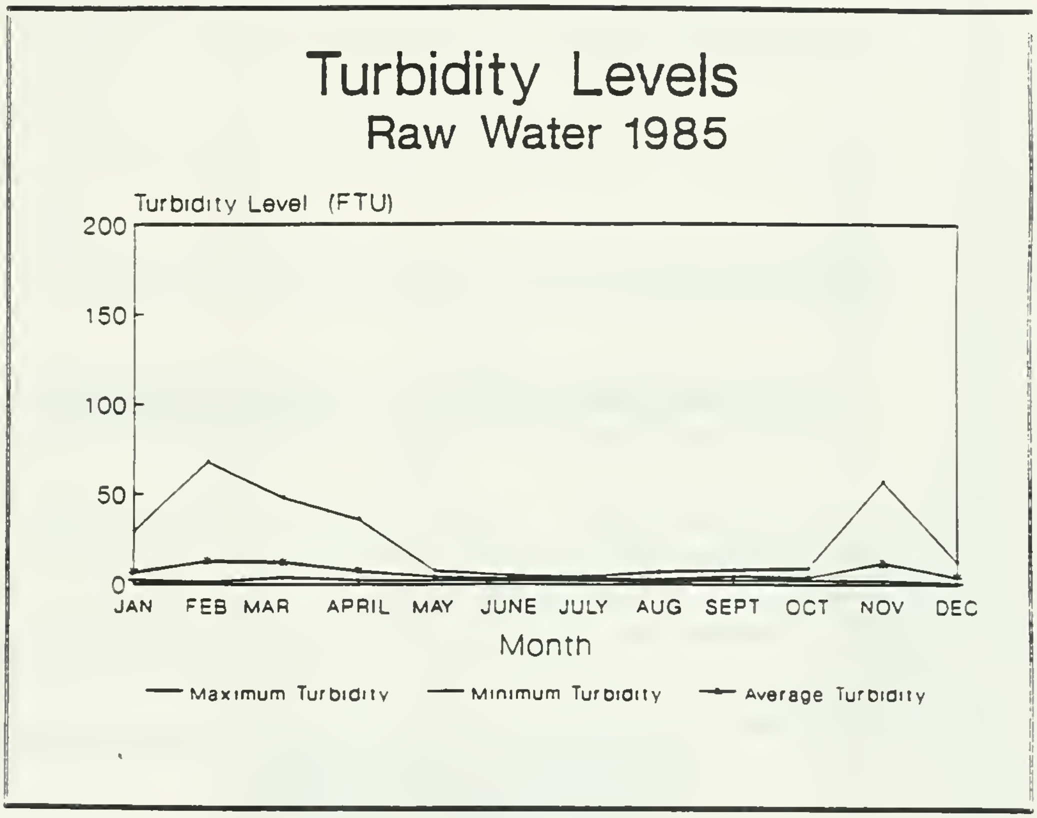
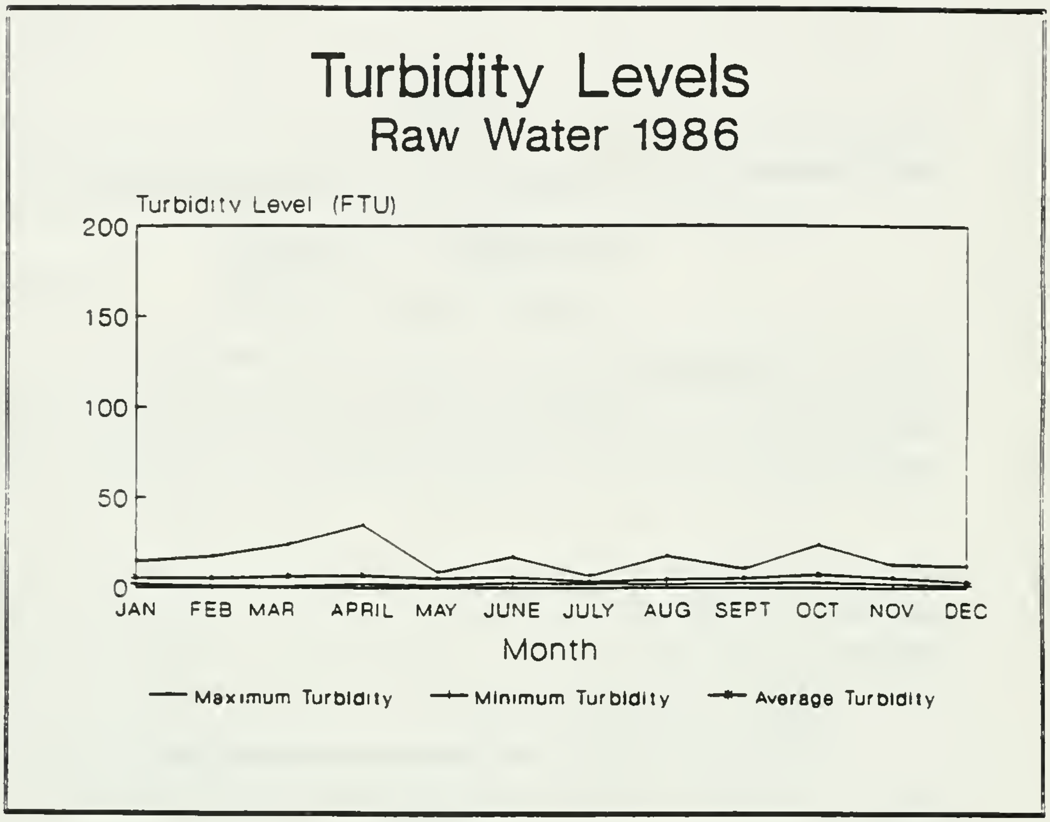

Turbidity Levels
Raw Water 1985
Turbidity Level (FTU)
200
150
100
50
0
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
Month
Maximum Turbidity
Minimum Turbidity
Average Turbidity

Figure 4


Turbidity Levels
Raw Water 1986
Turbidity Level (FTU)
200
150
100
50
0
JAN FEB MAR APRIL MAY JUNE JULY AUG SEPT OCT NOV DEC
Month
Maximum Turbidity
Minimum Turbidity
Average Turbidity

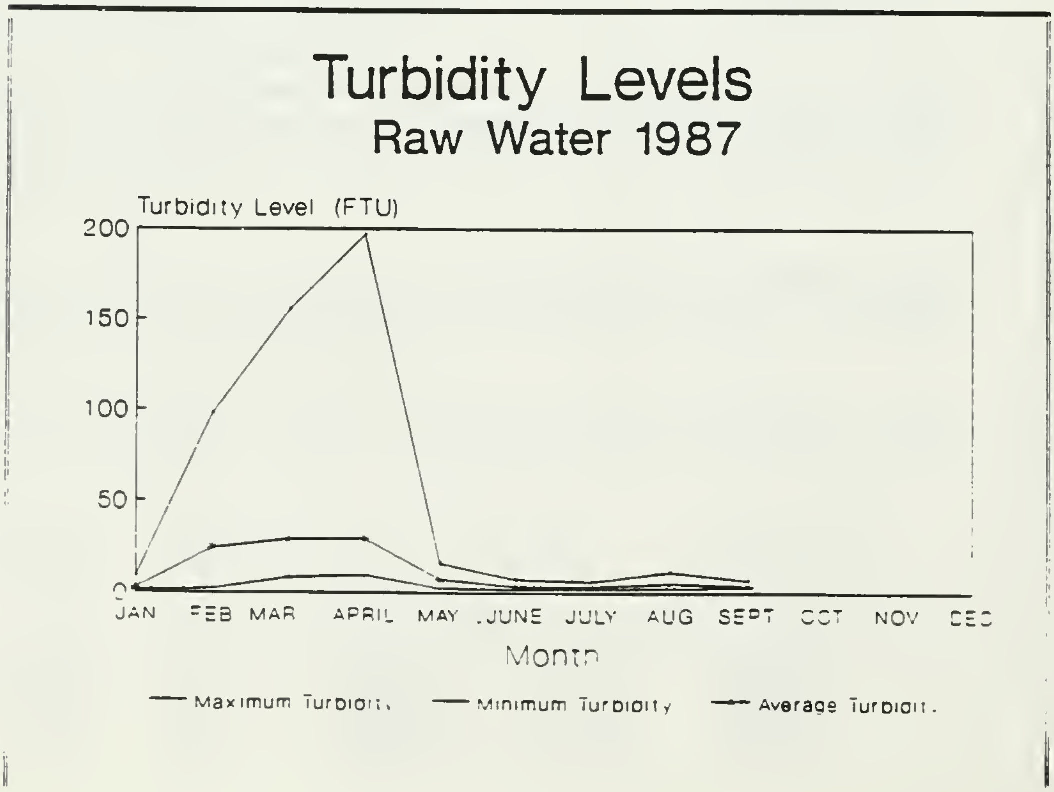
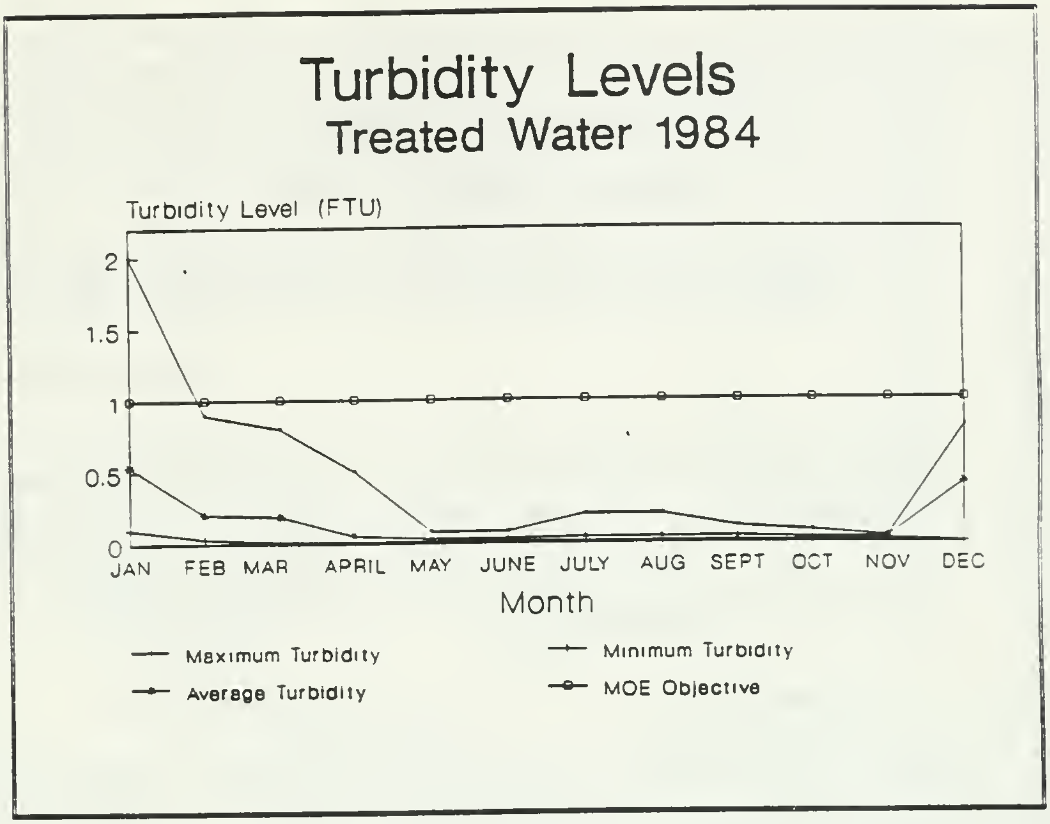
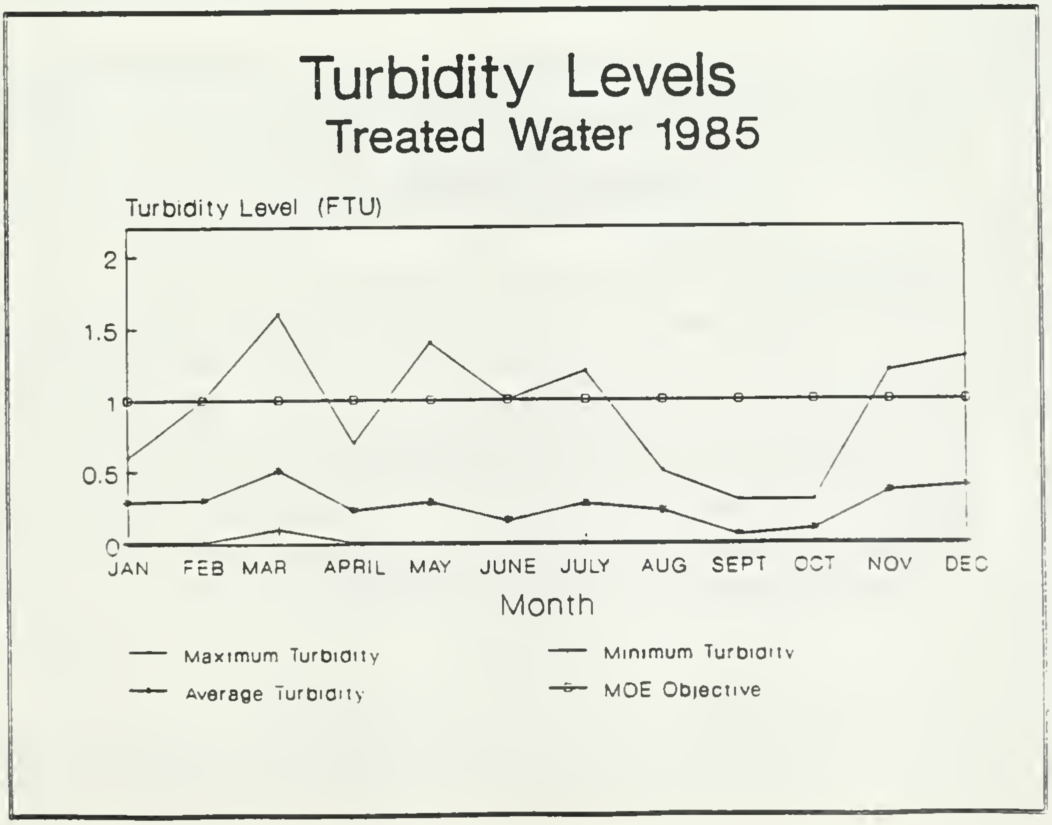

Turbidity Levels
Raw Water 1987
Turbidity Level (FTU)
200
150
100
50
0
JAN FEB MAR APRIL MAY JUNE JULY AUG SEPT OCT NOV DEC
Month
Maximum Turbidity
Minimum Turbidity
Average Turbidity

Figure 5


Turbidity Levels
Treated Water 1984
Turbidity Level (FTU)
2
1.5
1
0.5
0
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
Month
Maximum Turbidity
Minimum Turbidity
Average Turbidity
MOE Objective


Turbidity Levels
Treated Water 1985
Turbidity Level (FTU)
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1.5
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0.5
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JAN
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Maximum Turbidity
Minimum Turbidity
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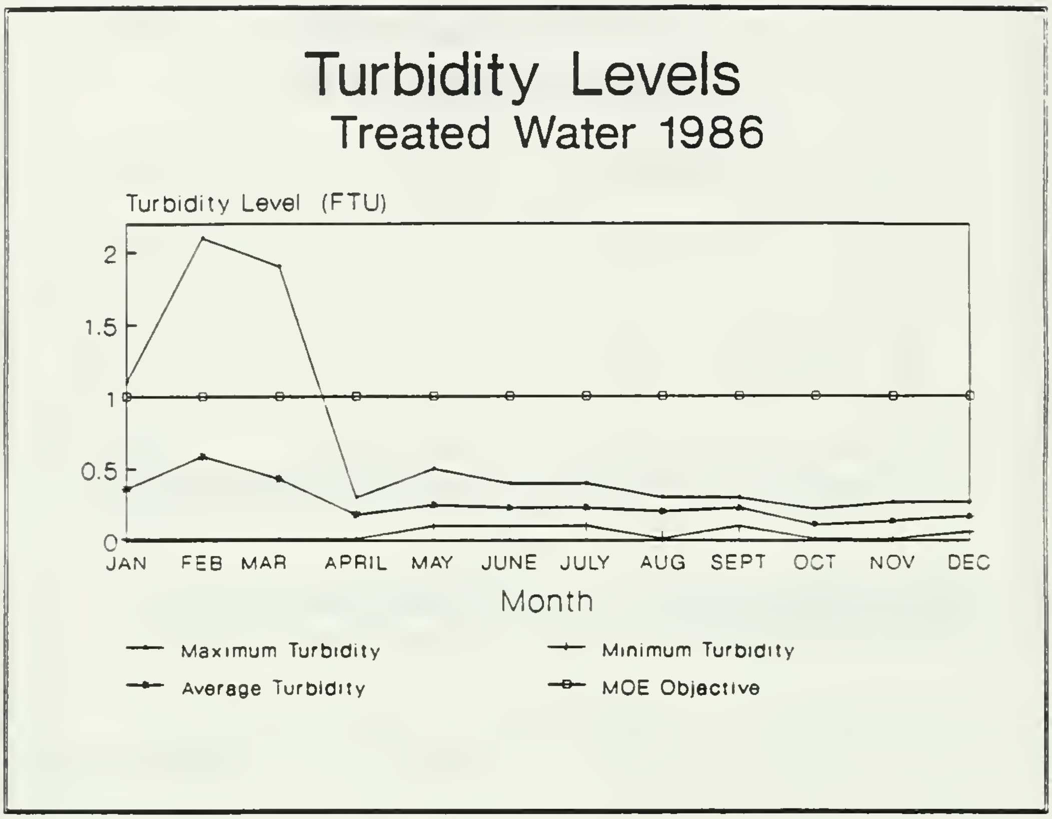
MOE Objective

Figure 5


Turbidity Levels
Treated Water 1986
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JAN
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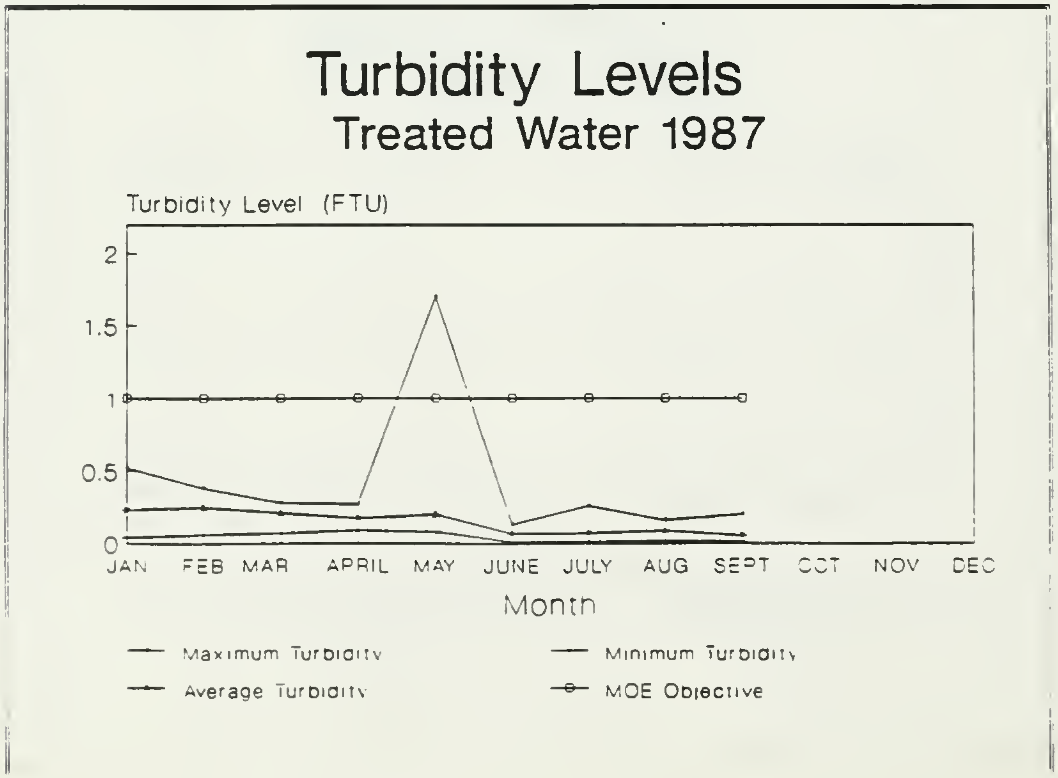
Average Turbidity
MOE Objective


Turbidity Levels
Treated Water 1987
Turbidity Level (FTU)
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1.5
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0.5
0
JAN
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MAR
APRIL
MAY
JUNE
JULY
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SEPT
OCT
NOV
DEC
Month
Maximum Turbidity
Minimum Turbidity
Average Turbidity
MOE Objective

The average level of aluminum measured in the raw water was 0.112 mg/L. The average level in treated water was 0.051 mg/L. Nevertheless, there were two instances of exceedance of the objective of 0.1 mg/L during 1986. On July 16, 1986 the aluminum level in the treated water was 0.130 mg/L while the level in the raw water was measured at 0.045 mg/L. On May 21, 1986, the level in the treated water was 0.110 mg/L with the corresponding concentration in the raw water measured at 0.140 mg/L. Elevated levels of aluminum in the treated water are likely associated with the addition of alum during the treatment process.

E:3 DISINFECTION

Disinfection is achieved by chlorination with powdered calcium hypochlorite mixed into solution. Chlorination is applied at two locations; after filtration and to the water pumped from the storage reservoir referred to as post-chlorination. The chlorine dosages are in the following range:

Pre-chlorination	Post-chlorination
1.0-2.0 mg/L	0.0-1.0 mg/L

The bacteriological quality of the treated water is monitored by the Lambton Health Unit in Sarnia. The fecal coliform count was reported as Absent for all samples of treated water. The total coliform count was reported as <2 or Absent for all samples of treated water. These results meet the Ministry of Health's requirement for safe drinking water.

The measured total chlorine residuals after post-chlorination are in the order of 0.6-1.2 mg/L. The free chlorine residual is reported to be in the range of 0.4-1.0 mg/L. There is an optimum level of chlorine residual in the treated water. Although too low of a residual can indicate insufficient potential for disinfection, excessive levels of residual may result in poor consumer acceptance.

A concern associated with chlorination is the formation of chlorinated by-products, in particular those categorized as trihalomethanes (THM). During the DWSP, the average level of trihalomethanes measured in the treated water was 40 ug/L. The maximum level was 65 ug/L measured November 6, 1985. The level of trihalomethanes in the raw water was below the detection limit. Although these values are below the drinking water objective of 350 ug/L, the level should be monitored regularly. The relocation of the point of pre-chlorination from the raw water line to after filtration should reduce the potential for formation of chlorinated by-products.

E:3 OTHER

The presence of organic compounds such as benzene and carbon tetrachloride is of particular concern because of the potential for chemical spills into the St. Clair River.

The Drinking Water Objective for benzene is 10 ug/L. The maximum level measured in the raw water was 5.0 ug/L on December 17, 1985 and January 6, 1986. The corresponding levels in the treated water were 3.0 ug/L. The maximum level in the treated water was 4.0 ug/L measured on December 23, 1985. The corresponding raw water level was below the detection limit.

The Drinking Water Objective for carbon tetrachloride is 3.0 ug/L. The maximum level measured in the treated water was 2.0 ug/L occurring on January 6, 1986 and February 24, 1986. On this occasion, the corresponding levels measured in the raw water samples were 1.0 ug/L and less than the detection limit respectively. The possible explanation for this anomaly is the accuracy of the analysis.

A feed line for the addition of powdered activated carbon (PAC) was installed in January 1986. PAC was applied to absorb any chemical contaminants that may be present in the St. Clair River in response to the potential for chemical spills. The PAC will enhance taste and odour control.

The treatment plant filters are backwashed on the average once per day. Backwash is initiated by filter headloss or manually by the operator. On the average, about 30,000 litres of treated water are used per backwash. On the basis of the plant production, which is in the order of 400,000 litres per day, the volume of water used for backwash is about 7.5 percent of the product water.

F. RECOMMENDATIONS

F:1 SHORT-TERM MODIFICATIONS

It is recommended that additional sampling be conducted. The additional information will assist in the day to day operation of the plant and will also provide data for future analysis and study. In particular, monthly sampling is recommended for aluminum, benzene, carbon tetrachloride and trihalomethanes. The analysis may be done as part of regular sampling sent to an outside laboratory. Full Drinking Water Surveillance Program sampling is recommended.

It is recommended that the continuous chart recorder for treated water flows be connected. Although not essential for evaluating treatment plant performance, the pattern of peak flows is useful to determine demand requirements when planning for future expansion.

It is recommended that the continuous chart recorder for the measurement of treated water turbidity levels be connected as the raw water turbidity level can fluctuate considerably within a 24 hour period. Also an alarm should be connected to alert the operator when the treated water turbidity exceeds the maximum acceptable concentration of 1.0 FTU.

It is recommended that both raw and treated water meters be calibrated annually. The dosage rate of the chemical feed pumps should be verified three to four times per year.

It is recommended that the effluent from the backwash settling tank be sampled several times per year before discharge to the St. Clair River.

It is recommended that the turbidity of the treated water be monitored immediately after the plant is returned to service following a backwash cycle. If there is an initial point of high turbidity, the magnitude and duration of the initial turbidity should be recorded. Consideration should be given to discharge to waste the first slug of production after backwashing.

In 1988 treatment plant operated at about 50 percent of its rated capacity operating on an ON-OFF basis. An alternative mode of operation during the months of low water demand, is to run the plant for longer periods at a lower flow rate. This could be achieved by throttling the output of the raw water pumps using one of the butterfly valves on the header pipe. This would require a corresponding adjustment to the chemical feed rates. During the summer months of 1988, the plant operated in excess of 75 percent of its rated capacity and therefore this mode of operation is considered practical only during seasons of low demand. The increased chemical reaction times, decreased settling and filtering rates may increase the quality of the treated water and reduce chemical consumption.

The implementation of the above recommendations involve both increased operator activity and some minor modifications to the plant. The approximate costs have been estimated as follows:

Capital Cost

Plant modification electrical and mechanical services	$5,000

Operating Cost (per year)

operator labour average 100 man hours/year	$2000
additional laboratory analysis	$12,000
additional reagents, etc.	$2,000
	$16,000

F:2 LONG TERM MODIFICATIONS

It is recommended that a study be conducted to review current requirements, update projected demands, and estimate the timing when additional supply is required. The study should consider the expansion of the plant as well as investigate alternate sources of supply such as proposed in the Lambton-North Kent Area Water Supply Study (M.M. Dillon, 1987). The treatment plant building and pumping equipment was designed with provision for the installation of a second package plant unit identical to the first. The installation of a second unit would double the capacity of the plant.

As part of the design of a future expansion, a continuous chemical feed control should be considered. This would involve a feedback loop from the continuous turbidity monitoring of treated water to regulate the chemical feed rate of alum and polyelectrolyte.

APPENDIX A

WATER PLANT OPTIMIZATION STUDY

OPTIMIZATION PROTOCOL
INCLUDING
GENERAL TERMS OF REFERENCE
FOR THE
PLANT CONSULTANT

Ontario Ministry of the Environment

Water Resources Branch

August 1986

06/04/87 (REV. 1)

WATER PLANT OPTIMIZATION STUDY

This document was prepared by K.J. Roberts, R.B. Hunsinger, and G.W. Martin of the Ministry of the Environment (MOE) Water Resources Branch and W.J. Hargrave of Gore & Storrie Limited. Revisions were carried out in conjunction with G. Sigal of R.V. Anderson Associates Limited and J. Budziakowski of the MOE Environmental Approvals and Land Use Planning Branch.

Ministry of the Environment
Water Resources Branch
Drinking Water Section
1 St. Clair Avenue West
Toronto, Ontario
M4V 1K6

06/04/87 (REV. 1)

Introduction

The information contained herein consists of a preamble and general terms of reference for the "Plant Consultant".

Basic Premise of the Water Plant Optimization Study

The majority of drinking water supply facilities in Ontario have treatment directed at microbiological disinfection and/or removal of suspended material.

The purpose of the Water Plant Optimization Study (WPOS) is to document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

The following items relate to the emphasis on particulate removal in a plant evaluation:

- Organic contaminants (dioxins, PAHs) are associated, at least in part, with particulates.
- Particulates themselves have health-related limits (turbidity/bacteria).
- In striving for excellence in water treatment, it is important to examine all possible approaches, but first optimum use should be made of the processes already in place.

The Drinking Water Surveillance Program (DWSP) is a continuously updated base of information on Ontario water plants and water quality. Appended herewith is a detailed description of the DWSP and the DWSP Questionnaire (Appendix A). In connection with the DWSP, a plant investigation and process evaluation study is required for each plant entering the program.

The Drinking Water Surveillance Program and the Water Plant Optimization Study are being co-ordinated for the following reasons:

- Some of the components of interest are the same, and cost savings can be realized.
- The DWSP should focus on plants which have been optimized and are producing the best possible water; documentation of plants which are known to be inefficient is non-productive.

General Information

1. Operator training and certification is an important component of plant optimization. Plans are already underway with the MOE/Municipal Engineers Association (MEA) to implement such a program.

2. The mechamism for ensuring ongoing optimization will be through an annual inspection by MOE staff or consultants, or a combination of the two.

3. The study has been organized with a team approach in mind; thus, progress reports and a meeting with the Project Committee are required as the work progresses.

4. It is not the intent of this study to provide a detailed implementation scheme for plant rehabilitation; however, it is necessary to scope the feasible short and long-term process modification, if required, to achieve optimum disinfection and contaminant removal.

5. All information provided in the study must conform to the Ministry's "Metrication Guidelines for Consulting Engineers", and existing information used for all designs, drawings, specifications, etc., for this project must also be converted into metric (SI) units.

Organization

On the following page is an organization chart which describes the various groups involved in each plant study.

Project Committee

A "Project Committee" will be struck for each water plant. The "Project Committee" will consists of Municipal and MOE representatives and a "Prime Consultant". The "Project Committee" will formulate a set of specific terms of reference for the "Plant Consultant", using the "General Terms of Reference" contained herein as the basis. It is important that the same general approach be utilized for all plants; therefore, only some specific inclusions should be allowed in the plant specific terms of reference.

The "Project Committee" will direct the "Plant Consultant" in carrying out work described in the plant specific terms of reference. The "Project Committee" will also review the progress of the work and evaluate the final report.

WATER PLANT OPTIMIZATION STUDY

Reporting & Co-ordination

MOE UPPER MANAGEMENT

C.E. McIntyre & J.N. Bishop

CO-ORDINATION GROUP

K. Roberts   G. Martin
R. Hunsinger   W. Gregson
J. Budziakowski

41 PROJECT COMMITTEES

1. Prime Consultant
2. Municipal Management
3. Municipal Operation
4. MOE Regional Representative
5. MOE Water Resources Branch
6. MOE Project Engineering Branch
7. MOE Environmental Approvals Branch

41 PLANT CONSULTANTS

Prime Consultant

The "Prime Consultant" for the study will co-ordinate all of the water plant optimization studies by carrying out such tasks as:

- Setting up project committees
- Participate in development of the specific terms of reference for each plant
- Liaison with "Plant Consultants" regarding progress reports, meetings, and final reports.
- Preparation of a report summarizing the results of the 41 plant studies.

Plant Consultant

The "Plant Consultant" will carry out the data gathering, interpretating and recommendation steps outlined in Tasks 1 through 8.

The "Plant Consultant" must provide staff with extensive experience in evaluation of existing water treatment facilities who will maintain direct involvement in all phases of the project.

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more that one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.

APPENDIX B

WATER PLANT OPTIMIZATION STUDY

TABLE 1.0: FLOWS (cu.m)

		1987			1986			1985			1984		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R	449	258	363	443	261	366	548	256	362	446	259	334
	T	405	227	327	407	276	355	370	267	313	444	255	303
FEB	R	531	250	357	679	258	359	369	228	289	346	140	305
	T	434	242	320	625	267	320	344	218	279	316	238	274
MAR	R	403	286	343	559	260	345	517	230	274	403	247	317
	T	364	247	300	513	243	312	498	210	264	351	249	295
APR	R	529	242	354	493	293	363	402	217	299	373	225	307
	T	439	229	294	391	173	309	353	174	284	351	232	307
MAY	R	458	279	376	606	57	410	540	106	329	484	220	311
	T	432	265	348	406	207	349	377	268	313	372	241	298
JUN	R	539	341	447	788	132	404	395	252	336	464	275	396
	T	510	325	408	463	273	333	397	276	325	412	259	340
JUL	R	503	272	417	517	307	411	874	327	412	463	300	361
	T	539	260	395	443	284	364	448	320	385	411	277	333
AUG	R	515	224	421	612	189	405	842	296	419			333
	T	500	303	394	464	327	373	549	311	390	437	267	355
SEP	R	703	342	458	478	275	349	465	129	366			
	T	559	330	427	376	238	310	444	266	344	437	245	325
OCT	R				550	263	338	597	195	343			343
	T				352	249	302	488	228	223	347	224	343
NOV	R				516	269	348	878	190	319	744	17	397
	T				472	243	316	333	250	284	634	264	363
DEC	R				398	279	346	594	158	380	447	247	317
	T				358	268	311	421	307	349	407	234	295

R = RAW ; T = TREATED

NOTES FOR TABLE 1.0 WATER QUANTITY

Table 1.0 documents the quantity of water pumped at the Walpole Island Treatment plant. The design capacity of the treatment plant is 959,000 litres per day (11.1 L/s). The maximum day demand for treated water occurred in November 1984 at 634,000 litres per day or about 66 percent of the design plant capacity. For the period of data in 1987, average production was in the range of 357,000 litres per day or about 37 percent of the design plant capacity.

The raw water flows are consistently higher than the treated water flows by an approximate value of 30,000 litres per day. This difference is attributed to the backwash cycle. The water for the filter backwash is drawn from the treated water meter. The plant is backwashed on an average of once per day using approximately 25,000 to 30,000 litres of water per cycle.

In some cases a reasonable interpretation of the data was required to account for some minor discrepancies in the recording of the meter readings. Following are explanatory notes for any extreme data including operators notes from the log sheet if available.

1. August to October, 1984 raw water data missing

   Raw water meter removed for repairs August 12, 1984 to October 18, 1984.

2. February 1984 raw water minimum

   value of 140 cu.m. recorded February 4, 1984
   Operators notes: February 4 manual operation of plant-alum motor burnt out.

3. November 1984 raw water minimum

   value of 17 cu.m. recorded November 4, 1984
   Operators notes: November 2 - Plant did not backwash; plant flooded.
   November 3 - Plant on manual filling south reservoir.
   November 4 - Plant off.
   November 5 - Plant on; filling south reservoir.
   November 7 - Plant on; filling north reservoir.

4. September 1985 raw water minimum

   value of 129 cu.m. recorded September 19, 1985
   Operators notes: September 19 - Plant off all night.

5. May 1986 raw water minimum

value of 57 cu.m. recorded May 23, 1986
Operators notes: May 23 - Plant shut down - charcoal replaced

TABLE 1.1: PER CAPITA CONSUMPTION (L/D/CAPITA)

CONSUMPTION	1987	1986	1985	1984
POPULATION (1)	1719	1642	1571	1528
MAXIMUM DAY	325	381	349	415
MINIMUM DAY	132	105	111	147
AVERAGE DAY	208	186	199	209
RATIO MD:AD	1.6	2.0	1.8	2.0

NOTES FOR TABLE 1.1 PER CAPITA CONSUMPTION

Table 1.1 documents the per capita flows for the population served by the treatment plant. Population data refers to on-Reserve Band Members, referenced to Reserves in Trust, Indian and Northern Affairs Canada (INAC).

WATER PLANT OPTIMIZATION STUDY

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	Turbidity (FTU)		R	8.90	1.30	2.68	14.60	2.00	5.35	29.00	2.20	6.23	11.60	1.00	
			T	0.52	0.04	0.23	1.10	<W	0.36	0.60	<W	0.29	2.00	0.10	0.54
	Colour (TCU)		R				13.00	2.50	7.30						
			T				1.00	<W	<W						
	* Prime Coagulant	(mg/L)		12.00	6.00	8.52	20.00	12.00	12.86			32.30			79.00
	** Coagulant Aid	(mg/L)		0.80	0.30	0.51	0.50	0.25	0.29			0.09			0.39
	*** (1) PAC	(mg/L)		34.00	6.00	17.70			17.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R				0.22	0.05	0.11						
			T				0.04	0.04	0.04						
	pH		R	8.00	7.70	7.87	7.90	7.80	7.87	7.80	7.60	7.73			
			T	7.90	7.70	7.84	7.80	7.20	7.50	7.40	7.20	7.30	7.80	7.60	7.76
	Temperature	(Deg.C.)		5.00	0.50	3.34									
FEB	Turbidity (FTU)		R	98.00	2.40	24.38	17.60	1.00	5.15	68.00	1.40	12.76			
			T	0.38	0.06	0.25	2.10	<W	0.59	1.00	<W	0.30	0.90	0.03	0.20
	Colour (TCU)		R				5.00	3.00	3.80						
			T				<W	<W	<W						
	* Prime Coagulant	(mg/L)		30.00	6.00	19.61	12.00	12.00	12.00			43.20			41.20
	** Coagulant Aid	(mg/L)		2.50	0.30	0.79	0.25	0.25	0.25			0.17			0.16
	*** (1) PAC	(mg/L)		12.00	6.00	8.35			17.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R				0.05	0.03	0.04						
			T				0.05	0.04	0.04						
	pH		R	7.90	7.80	7.87	7.60	7.60	7.60			7.80			
			T	7.80	7.50	7.67	7.40	7.30	7.35			7.30			7.80
	Temperature	(Deg.C.)		2.00	0.00	1.00									

* Prime Coagulant - Alum

** Coagulant Aid - Polyelectorolyte

*** (1) PAC - Powdered Activated Carbon

TABLE 2.0: PARTICULATE REMOVAL SUMMARY (CONT'D)

	PARAMETER			1987 MAX.	1987 MIN.	1987 AVG.	1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.
MAR	Turbidity (FTU)		R	155.00	8.40	28.97	24.00	0.60	6.36	48.00	4.10	12.12			
			T	0.28	0.07	0.21	1.90	<W	0.43	1.60	0.10	0.51	0.80	0.01	0.19
	Colour (TCU)		R			2.50			11.50						
			T			<W			1.00						
	* Prime Coagulant	(mg/L)		38.00	12.50	28.98	25.00	10.00	19.19			53.20			55.50
	** Coagulant Aid	(mg/L)		0.45	0.25	0.41	0.80	0.10	0.30			0.36			0.61
	*** (1) PAC	(mg/L)		12.00	12.00	12.00			26.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R			0.57			0.57						
			T			0.05			0.05						
	pH		R	7.70	7.50	7.53	7.90	7.40	7.73						7.60
			T	7.10	6.80	6.92	7.90	6.80	7.38						7.20
	Temperature	(Deg.C.)		4.50	0.50	1.90									
APR	Turbidity (FTU)		R	197.00	9.60	29.40	35.00	2.30	7.02	36.00	2.20	7.34			
			T	0.27	0.09	0.17	0.30	<W	0.18	0.70	<W	0.23	0.50	0.01	0.05
	Colour (TCU)		R				4.00	1.00	2.20						
			T				1.00	<W	<W						
	* Prime Coagulant	(mg/L)		40.00	10.00	19.47	30.00	5.00	9.27			50.50			29.50
	** Coagulant Aid	(mg/L)		0.88	0.20	0.33	0.38	0.00	0.19			0.27			0.26
	*** (1) PAC	(mg/L)		6.00	6.00	6.00	22.00	22.00	22.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R				0.12	0.02	0.07						
			T				0.06	0.04	0.04						
	pH		R			7.90	8.00	7.70	7.88	7.50	7.20	7.35			7.60
			T			6.90	7.60	7.40	7.55	7.00	6.80	6.90			7.20
	Temperature	(Deg.C.)		7.50	2.80	5.40									

* Prime Coagulant - Alum

** Coagulant Aid - Polyelectorolyte

*** (1) PAC - Powdered Activated Carbon

TABLE 2.0: PARTICULATE REMOVAL SUMMARY (CONT'D)

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
MAY	Turbidity (FTU)		R	16.30	2.60	7.69	8.70	1.40	5.15	7.60	2.30	4.43			
			T	1.70	0.08	0.20	0.50	0.10	0.25	1.40	<W	0.29	0.08	0.01	0.03
	Colour (TCU)		R						3.00						
			T						1.00						
	* Prime Coagulant	(mg/L)		20.00	10.00	11.77	22.00	5.00	10.23			35.60			37.80
	** Coagulant Aid	(mg/L)		0.35	0.10	0.22	0.30	0.30	0.30			0.06			0.21
	*** (1) PAC	(mg/L)		6.00	6.00	6.00	22.00	22.00	22.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R						0.14						
			T						0.11						
	pH		R				8.10	7.80	7.90	7.90	7.90	7.90			7.80
			T				7.60	7.40	7.53	7.30	7.20	7.25			7.20
	Temperature	(Deg.C.)		15.00	7.50	10.80	13.00	7.00	10.29						
JUN	Turbidity (FTU)		R	7.60	2.00	3.62	17.00	2.80	6.08	4.90	2.10	3.17			
			T	0.13	0.01	0.07	0.40	0.10	0.23	1.00	<W	0.16	0.08	0.01	0.03
	Colour (TCU)		R						2.50						
			T						<W						
	* Prime Coagulant	(mg/L)		6.00	3.00	5.60	10.00	5.00	6.22			36.10			30.60
	** Coagulant Aid	(mg/L)		1.50	0.00	0.70	0.30	0.30	0.30			0.01			0.19
	*** (1) PAC	(mg/L)		6.00	6.00	6.00	30.00	22.00	24.76						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R						0.20						
			T						0.80						
	pH		R	8.10	7.80	7.94	8.10	8.00	8.03			7.70	8.20	7.90	8.05
			T	7.60	7.20	7.45	7.80	7.60	7.67			7.30	7.30	7.20	7.25
	Temperature	(Deg.C.)		20.00	13.00	16.40	16.50	12.00	14.52						

TABLE 2.0: PARTICULATE REMOVAL SUMMARY (CONT'D)

				1987			1986			1985			1984		
	PARAMETER			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JUL	Turbidity (FTU)		R	6.20	2.20	3.59	6.60	2.40	3.64	4.20	2.10	3.20			
			T	0.26	0.01	0.07	0.40	0.10	0.23	1.20	<W	0.28	0.20	0.01	0.04
	Colour (TCU)		R						2.50						
			T						1.00						
	* Prime Coagulant	(mg/L)		6.00	1.50	2.81	7.50	3.00	5.24			42.50			32.40
	** Coagulant Aid	(mg/L)		0.25	0.25	0.25	0.70	0.20	0.24						0.16
	*** (1) PAC	(mg/L)		6.00	6.00	6.00	22.00	22.00	22.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R						0.05						
			T						0.13						
	pH		R	8.10	7.70	7.89	8.20	7.60	7.95			7.90			
			T	7.50	7.10	7.34	8.10	7.50	7.67			7.10			
	Temperature	(Deg.C.)		24.00	18.50	21.30	21.50	16.00	18.71						
AUG	Turbidity (FTU)		R	11.50	2.60	5.17	17.70	2.00	4.59	6.90	2.00	3.14			
			T	0.16	0.02	0.09	0.30	<W	0.20	0.50	<W	0.23	0.20	0.01	0.04
	Colour (TCU)		R												
			T												
	* Prime Coagulant	(mg/L)		15.00	5.00	5.90	5.00	5.00	5.00			41.90			
	** Coagulant Aid	(mg/L)		1.25	0.00	0.89	0.30	0.30	0.30			0.15			
	*** (1) PAC	(mg/L)		6.00	4.50	5.32	22.00	22.00	22.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.60	8.00	8.46	8.10	7.70	7.89	7.90	7.60	7.75			8.10
			T	7.70	6.80	7.03	7.70	7.50	7.52	7.30	7.00	7.15			7.20
	Temperature	(Deg.C.)		25.00	18.80	21.40	22.00	19.00	21.25						

* Prime Cogaulant - Alum
** Coagulant Aid - Polyelectrolyte
*** (1) PAC - Powdered Activated Carbon

TABLE 2.0: PARTICULATE REMOVAL SUMMARY (CONT'D)

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
SEP	Turbidity (FTU)		R	6.90	3.00	4.14	10.60	2.70	5.45	7.90	2.50	4.67			
			T	0.20	<W	0.05	0.30	0.10	0.23	0.30	<W	0.06	0.11	0.01	0.04
	Colour (TCU)		R												
			T												
	* Prime Coagulant	(mg/L)		8.50	3.00	4.80	12.00	4.00	5.17			37.10			42.40
	** Coagulant Aid	(mg/L)		1.75	1.50	1.68	1.50	0.12	0.59			0.27			0.26
	*** (1) PAC	(mg/L)		20.00	5.00	6.23	22.00	7.50	19.30						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R	8.50	8.00	8.40	8.20	7.70	7.98			7.90			
			T	7.50	7.00	7.23	7.80	7.30	7.56			7.10			7.30
	Temperature	(Deg.C.)		20.30	17.00	19.00	20.00	17.00	18.62						
OCT	Turbidity (FTU)		R				24.00	2.90	7.49	8.80	2.20	4.05			
			T				0.22	<W	0.11	0.30	<W	0.10	0.08	0.01	0.03
	Colour (TCU)		R												
			T												
	* Prime Coagulant	(mg/L)					12.00	2.00	5.92			12.80			42.80
	** Coagulant Aid	(mg/L)					0.25	0.20	0.21			0.16			0.23
	*** (1) PAC	(mg/L)					20.00	6.00	12.32						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R												
			T												
	pH		R				8.20	7.70	7.96			8.00			
			T				7.90	7.40	7.63			7.30			
	Temperature	(Deg.C.)					19.00	12.50	15.00						

* Prime Cogaulant - Alum

** Coagulant Aid - Polyelectrolyte

*** (1) PAC - Powdered Activated Carbon

TABLE 2.0: PARTICULATE REMOVAL SUMMARY (CONT'D)

	PARAMETER			1987			1986			1985			1984		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
NOV	Turbidity (FTU)		R				12.70	2.20	5.64	57.00	2.40	11.89			
			T				0.27	<W	0.14	1.20	<W	0.36	0.04	0.02	0.03
	Colour (TCU)		R							18.00	2.00	8.50			
			T							<W	<W	<W			
	* Prime Coagulant	(mg/L)					22.00	2.00	4.88			18.90			22.80
	** Coagulant Aid	(mg/L)					3.00	0.20	0.59			0.21			0.23
	*** (1) PAC	(mg/L)					6.00	6.00	6.00						
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R							0.25	0.02	0.14			
			T							0.09	0.02	0.06			
	pH		R				8.30	7.90	7.95	7.90	7.80	7.87	8.10	7.60	7.90
			T				7.90	7.10	7.70	7.70	7.50	7.60	7.20	7.20	7.20
	Temperature	(Deg.C.)					13.00	7.00	9.40						
DEC	Turbidity (FTU)		R				12.40	1.40	3.38	12.10	0.60	4.13	11.60	1.00	6.00
			T				0.27	0.06	0.17	1.30	<W	0.40	0.80	<W	0.41
	Colour (TCU)		R						1.50	5.00	2.50	3.40			
			T						1.00	<W	<W	<W			
	* Prime Coagulant	(mg/L)					7.00	3.00	4.52			19.20			18.50
	** Coagulant Aid	(mg/L)					0.30	0.00	0.11			0.22			0.19
	*** (1) PAC	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al	(mg/L)	R						0.03	0.30	0.03	0.11			
			T						0.07	0.04	0.03	0.04			
	pH		R				8.30	7.80	7.96	8.00	7.90	7.93	7.80	7.70	7.75
			T				7.90	7.70	7.87	7.50	7.30	7.43	7.20	7.20	7.20
	Temperature	(Deg.C.)					6.50	3.50	5.00						

* Prime Cogaulant - Alum

** Coagulant Aid - Polyelectrolyte

*** (1) PAC - Powdered Activated Carbon

NOTES FOR TABLE 2.0 PARTICULATE REMOVAL SUMMARY

Table 2.0 summarizes physical parameters of the raw and treated water and dosages of chemicals used for particulate removal.

Data for the physical parameters of turbidity, pH and temperature is shown as recorded daily on the plant log sheet. Missing data in the table indicates that these parameters were not recorded on the log sheet. The number of parameters and frequency of recording increase over the period from 1984 to 1987.

Turbidity values for raw water begin in December 1984 as the Hach type turbidimeter was acquired late in 1984. Values of pH are available for both raw and treated water but data was not consistently recorded on a daily basis. Temperature has been recorded for both raw and treated water starting in 1986, but only the raw water values have been documented in this report.

Some values of treated water turbidity were recorded as zero in the log sheet by the operator. It is assumed that these turbidity levels were below the detection level of the instrument and are therefore indicated by a '<W' symbol in this table.

The data for residual aluminum and colour was collected from the Drinking Water Surveillance Program water testing results published by the Ministry of the Environment. As this data is based on infrequent sampling, caution should be exercised in generalizing the results.

In the table, alum is designated as the as the prime coagulant, polyelectrolyte as the coagulant aid and powdered activated carbon as chemical (1) referred to as PAC. Feed rates for alum, polyelectrolyte and activated carbon were recorded in 1986 and 1987. Activated carbon was first added in January 1986 and so no data is available prior to this date. For alum and polyelectrolyte prior to 1986, only the mass weight of chemical was recorded each time it was added. The monthly average feed rate is determined by the total amount of chemical added during the month, divided by the total quantity of raw water treated.

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE   JANUARY 1984

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1				2.00													
2				1.00													
3				1.00													
4				1.00													
5				1.00													
6				1.00													
7				1.00													
8				2.00													
9				2.00													
10				0.50												7.80	
11				0.30													
12				0.20													
13				0.30													
14				0.20													
15				0.20													
16				0.40													
17				0.20												7.80	
18				0.20													
19				0.10													
20				0.10													
21				0.10													
22				0.10													
23				0.20												7.60	
24				0.10													
25				0.30													
26				0.20													
27				0.50													
28				0.10													
29				0.10													
30				0.10												7.80	
31				0.10												7.80	
MAX				2.00												7.80	
MIN				0.10												7.60	
AVG				0.54			79.00	0.39								7.76	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1984

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1				0.06													
2				0.02													
3				0.05													
4				0.03													
5				0.03											7.60	7.20	
6				0.05													
7				0.02													
8				0.02													
9				0.01													
10				0.01													
11				0.01													
12				0.01													
13				0.10													
14				0.10													
15				0.02													
16				0.01													
17				0.01													
18				0.01													
19				0.01													
20				0.01													
21				0.02													
22				0.04													
23				0.04													
24				0.04													
25				0.05													
26				0.10													
27				0.03													
28				0.03													
29				0.02													
30				0.02													
MAX				0.10													
MIN				0.01													
AVG				0.03			29.60	0.26							7.60	7.20	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1984

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1				0.02													
2				0.04													
3				0.06													
4				0.06													
5				0.05													
6				0.04													
7				0.02													
8				0.03													
9				0.02													
10				0.18													
11				0.02													
12				0.02													
13				0.06													
14				0.20													
15				0.02													
16				0.02													
17				0.02													
18				0.02													
19				0.02													
20				0.02													
21				0.02													
22				0.02													
23				0.02													
24				0.02													
25				0.02													
26				0.02													
27				0.02													
28				0.02													
29				0.02													
30				0.01													
31				0.02													
MAX				0.20													
MIN				0.01													
AVG				0.04			32.50	0.16									

TABLE 2.1: PARTICULATE REMOVAL PROFILE OCTOBER 1984

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1				0.04													
2				0.04													
3				0.04													
4				0.04													
5				0.04													
6				0.04													
7				0.04													
8				0.05													
9				0.05													
10				0.05													
11				0.04													
12				0.04													
13				0.06													
14				0.02													
15				0.02													
16				0.02													
17				0.01													
18				0.02													
19				0.02													
20				0.04													
21				0.01													
22				0.08													
23				0.02													
24				0.02													
25				0.02													
26				0.02													
27				0.02													
28				0.02													
29				0.02													
30				0.02													
31				0.02													
MAX				0.08													
MIN				0.01													
AVG				0.03													

TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1985

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	10.10			0.40											7.70	7.20	
2	29.00			0.20													
3	11.80			0.30													
4	5.30			0.40													
5	3.00			0.30													
6	8.60			<W													
7	10.10			0.10													
8	7.80			0.40													
9	11.50			0.20											7.80	7.40	
10	8.40			0.50													
11	5.90			0.30													
12	6.70			0.20											7.60	7.20	
13	3.90			0.10													
14	5.40			0.10													
15	6.00			0.30													
16	4.60			0.30													
17	3.20			0.30													
18	4.00			0.30													
19	3.10			0.10													
20	5.20			0.30													
21	5.80			0.20													
22	4.80			0.20													
23	5.00			0.30													
24	3.30			0.20													
25	2.80			0.30													
26	3.00			0.60													
27	4.40			0.60													
28	2.20			0.40													
29	2.80			0.30													
30	2.60			0.40													
31	2.70			0.30											7.80	7.40	
MAX	29.00			0.60											7.80	7.40	
MIN	2.20			<W											7.60	7.20	
AVG	6.23			0.29			32.30	0.09							7.73	7.30	

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1985

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	36.00			0.50													
2	9.80			0.10													
3	9.20			0.30													
4	5.20			0.20													
5	5.00			0.10													
6	15.90			<W													
7	14.90			0.10													
8	5.50			0.20											7.20	6.80	
9	5.70			0.10													
10	6.10			0.20													
11	5.20			0.20													
12	5.10			0.20													
13	7.40			0.10													
14	8.30			0.10													
15	3.20			0.30													
16	2.20			0.10													
17	4.80			0.20											7.50	7.00	
18	6.70			0.20													
19	6.20			0.10													
20	11.60			0.30													
21	2.80			0.20													
22	3.10			0.10													
23	3.30			0.10													
24	3.80			0.30													
25	3.40			0.30													
26	3.20			0.30													
27	2.70			0.30													
28	6.60			0.50													
29	6.80			0.70													
30	10.40			0.40													
MAX	36.00			0.70											7.50	7.00	
MIN	2.20			<W											7.20	6.80	
AVG	7.34			0.23			50.50	0.27							7.35	6.90	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE   JULY 1985

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	2.60			0.30													
2	2.70			<W											7.90	7.10	
3	3.00			0.30													
4	2.20			0.10													
5	2.70			0.40													
6	2.10			0.20													
7	2.20			0.10													
8	3.60			0.30													
9	2.70			0.10													
10	2.90			0.40													
11	3.60			0.20													
12																	
13	3.90			0.30													
14	4.10			0.60													
15	3.50			0.30													
16	3.40			<W													
17				<W													
18	3.80			<W													
19	4.20			<W													
20	3.30			1.20													
21	2.70			0.20													
22	3.30			0.40													
23	3.70			0.30													
24	3.30			0.20													
25	4.00			0.30													
26	3.30			0.30													
27	3.00			0.40													
28	3.70			0.70													
29	3.50			0.30													
30	2.60			0.40													
31	3.30			0.20													
MAX	4.20			1.20											7.90	7.10	
MIN	2.10			<W											7.90	7.10	
AVG	3.20			0.28			42.50								7.90	7.10	

TABLE 2.1: PARTICULATE REMOVAL PROFILE OCTOBER 1985

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) PAC	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	4.50			0.10													
2	3.20			0.10													
3	2.40			<W													
4	2.60			<W													
5	6.40			0.30													
6	3.10			0.10													
7	2.60			0.10													
8	2.60			0.20													
9	2.70			0.30													
10	2.60			0.10													
11	3.70			0.20											8.00	7.30	
12	3.30			0.10													
13	3.30			0.10													
14	3.30			0.20													
15	2.20			0.10													
16	2.20			0.10													
17	3.00			<W													
18	4.20			0.10													
19	3.20			0.10													
20	8.30			0.10													
21	8.80			0.10													
22	5.90			<W													
23	5.60			<W													
24	3.40			0.10													
25	2.70			0.10													
26	2.20			0.10													
27	2.70			0.10													
28	2.60			<W													
29	7.00			0.10													
30	8.30			0.10													
31	6.80			<W													
MAX	8.80			0.30													
MIN	2.20			<W													
AVG	4.05			0.10			12.80	0.16							8.00	7.30	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE   JANUARY 1986

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	2.10			0.60											7.90	7.50	
2	3.60			0.40													
3	3.90			0.60			15.00	0.50									
4	3.60			0.50			15.00	0.50									
5	5.30			1.10			15.00	0.50									
6	4.10			0.40	3	<W	20.00	0.50					0.054	0.040			
7	4.30			0.50			20.00	0.50							7.90	7.80	
8	2.30			0.70			12.00	0.25									
9	2.00			0.20			12.00	0.25									
10	2.50			0.20			12.00	0.25									
11	3.50			0.50			12.00	0.25									
12	5.40			0.40			12.00	0.25									
13	3.20			0.20	2.5	<W	12.00	0.25					0.047	0.038			
14	11.10			0.10			12.00	0.25	17.00								
15	4.50			0.10			12.00	0.25	17.00								
16	4.90			0.10			12.00	0.25	17.00								
17	4.00			0.20			12.00	0.25	17.00								
18	5.90			0.30			12.00	0.25	17.00								
19	6.70			0.20			12.00	0.25	17.00								
20	13.30			<W	13	1	12.00	0.25	17.00				0.130	0.039			
21	14.60			0.50			12.00	0.25	17.00								
22	8.50			0.40			12.00	0.25	17.00								
23	7.40			0.20			12.00	0.25	17.00								
24	7.10			0.10			12.00	0.25	17.00								
25	3.90			0.70			12.00	0.25	17.00								
26	5.20			<W			12.00	0.25	17.00								
27	2.00			0.50	10.5	<W	12.00	0.25	17.00				0.220	0.042			
28	6.30			0.20			12.00	0.25	17.00						7.80	7.20	
29	6.10			0.30			12.00	0.25	17.00								
30	4.10			0.40			12.00	0.25	17.00								
31	4.40			0.70			12.00	0.25	17.00								
MAX	14.60			1.10	13.00		20.00	0.50	17.00				0.220		7.90	7.80	
MIN	2.00			<W	2.50		12.00	0.25	17.00				0.047		7.80	7.20	
AVG	5.35			0.36	7.25		12.86	0.29	17.00				0.113	0.040	7.87	7.50	

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1986

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	3.10			0.10	1.5	<W	14.00	0.25									
2	3.00			0.30			7.50	0.25					0.024	0.036	7.80	7.40	
3	2.40			0.20			7.50	0.25									
4	2.30			0.20			5.00	0.25									
5	4.00			0.30			5.00	0.25							8.00	7.60	
6							5.00	0.25									
7	3.70			<W			5.00	0.25	22								
8	3.00			<W			5.00	0.25	22								
9	2.30			0.10			5.00	0.25	22						7.80	7.60	
10	6.30			0.20			5.00	0.25	22								
11	6.00			0.20			7.50	0.25	22								
12	6.20			0.20			7.50	0.25	22								
13	3.30			0.20			7.50	0.25	22								
14	35.00			0.10			30.00	0.38	22								
15	14.20			0.10	4	<W	10.00	0.30	22				0.120	0.039	8.00	7.40	
16	10.20			0.30			10.00	0.30	22						8.00	7.60	
17	5.90			0.30			7.50	0.30	22								
18	11.20			0.20			12.00	0.30	22								
19	11.90			0.20			12.00	0.30	22								
20	3.80			0.20			10.00	0.30	22								
21	5.00			0.10			10.00	0.30	22								
22	9.00			0.10			10.00		22						7.70	7.50	
23	10.80			0.20			10.00		22								
24	12.60			0.10			10.00		22								
25	9.30			0.20			10.00		22								
26	6.80			0.30			10.00		22								
27	3.70			0.20			10.00		22								
28	2.70			0.30			10.00		22								
29	3.00			0.10	1	1	10.00		22						0.064	0.058	
30	2.80			0.20			10.00		22								
MAX	35.00			0.30			30.00	0.38	22.00						8.00	7.60	
MIN	2.30			<W			5.00		22.00						7.70	7.40	
AVG	7.02			0.18	2.17	0.33	9.27	0.19	22.00				0.07	0.04	7.88	7.52	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1986

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	4.50			0.20			5.00	0.30	22						8.20	7.70	
2	3.60			0.20			5.00	0.70	22								
3	4.10			0.30			5.00	0.70	22								
4	6.60			0.10			3.00	0.20	22								
5	5.30			0.20			3.00	0.20	22								
6	4.20			0.30			3.00	0.20	22								
7	3.50			0.30			3.00	0.20	22						8.10	7.70	
8	2.70			0.30			3.00	0.20	22						7.80	7.60	
9	2.90			0.30			3.00	0.20	22								
10	3.10			0.30			3.00	0.20	22								
11	3.50			0.20			3.00	0.20	22								
12	3.60			0.30			3.00	0.20	22								
13	4.50			0.20			3.00	0.20	22								
14	3.70			0.40			7.50	0.20	22						7.60	8.00	
15	2.80			0.30			7.50	0.20	22						7.60	8.10	
16	2.40			0.20	2.5	1	7.50	0.20	22				0.045	0.130	8.00	7.70	
17	3.10			0.20			7.50	0.20	22								
18	3.40			0.30			7.50	0.20	22						7.80	7.50	
19	3.50			0.30			7.50	0.20	22								
20	5.20			0.30			7.50	0.20	22								
21	3.90			0.30			7.50	0.20	22						8.00	7.50	
22	3.30			0.20			7.50	0.20	22								
23	3.60			0.20			7.50	0.20	22								
24	3.80			0.10			7.50	0.20	22								
25	3.80			0.10			5.00	0.20	22								
26	2.90			0.10			5.00	0.20	22						8.10	7.60	
27	3.40			0.20			5.00	0.20	22						8.10	7.60	
28	2.60			0.20			5.00	0.20	22						8.10	7.70	
29	2.40			0.20			5.00	0.20	22								
30	2.90			0.20			5.00	0.20	22						7.90	7.50	
31	3.90			0.20			5.00	0.20	22						8.00	7.50	
MAX	6.60			0.40			7.50	0.70	22.00						8.20	8.10	
MIN	2.40			0.10			3.00	0.20	22.00						7.60	7.50	
AVG	3.64			0.23	2.50	1.00	5.24	0.24	22.00				0.05	0.13	7.95	7.67	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE   OCTOBER 1986

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	6.00			0.20			5.00	0.20	20						8.00	7.50	
2	7.20			0.22			5.00	0.20	20						8.00	7.50	
3	7.50			0.20			5.00	0.20	20						8.00	7.60	
4	8.60			0.20			5.00	0.20	20						7.80	7.60	
5	8.90			0.10			5.00	0.20	20								
6	8.20			0.20			7.50	0.20	20						8.20	7.70	
7	10.90			0.10			7.50	0.20	20						8.20	7.70	
8	7.80			0.20			7.50	0.20	20						8.10	7.60	
9	8.60			0.10			7.50	0.20	20						8.00	7.50	
10	18.50			0.10			12.00	0.20	20						7.70	7.60	
11	24.00			0.20			12.00	0.20	20						8.00	7.60	
12	12.20			0.10			12.00	0.20	20						8.00	7.60	
13	13.00			0.10			12.00	0.20	20						8.00	7.50	
14	7.70			0.20			5.00	0.20	20						8.00	7.40	
15	5.20			0.10			5.00	0.20	6						7.90	7.50	
16	4.20			0.10			5.00	0.20	6						7.90	7.80	
17	3.90			0.10			5.00	0.20	6						7.90	7.50	
18	9.10			0.10			5.00	0.20	6						7.90	7.80	
19	8.50			<W			5.00	0.20	6						7.90	7.60	
20	5.80			0.17			5.00	0.20	6								
21	4.60			<W			5.00	0.20	6						7.80	7.70	
22	4.50			<W			5.00	0.20	6						7.90	7.60	
23	4.00			<W			5.00	0.20	6						8.00	7.70	
24	3.00			<W			5.00	0.20	6						8.10	7.90	
25	2.90			<W			5.00	0.20	6								
26	4.60			<W			5.00	0.20	6								
27	4.60			0.08			2.00	0.20	6						7.90	7.70	
28	3.20			0.07			2.00	0.25	6						7.90	7.70	
29	5.90			0.10			2.00	0.25	6						7.90	7.60	
30	3.60			0.10			2.00	0.25	6						7.90	7.70	
31	5.40			0.20			2.00	0.25	6						7.90	7.80	
MAX	24.00			0.22			12.00	0.25	20.00						8.20	7.90	
MIN	2.90			<W			2.00	0.20	6.00						7.70	7.40	
AVG	7.49			0.11			5.92	0.21	12.32						7.96	7.63	

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1987

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	2.00			0.12			6.00	0.30	6.0						7.90	7.90	4.5
2	1.90			0.18			6.00	0.30	6.0						7.90	7.90	4.0
3	1.40			0.12			6.00	0.30	6.0						8.00	7.90	5.0
4	3.10			0.21			6.00	0.30	6.0						7.70	7.90	5.0
5	1.70			0.21			6.00	0.30	6.0						7.90	7.90	4.0
6	1.70			0.21			6.00	0.30	6.0						7.90	7.90	3.5
7	1.90			0.15			6.00	0.30	6.0						7.90	7.90	4.0
8	2.50			0.05			6.00	0.30	6.0						7.90	7.90	4.5
9	2.20			0.21			6.00	0.30	6.0						7.90	7.80	4.0
10	1.80			0.19			6.00	0.30	6.0						7.90	7.70	5.0
11	1.40			0.17			6.00	0.30	6.0						7.90	7.70	5.0
12	4.00			0.14			6.00	0.30	6.0						7.90	7.90	3.0
13	3.30			0.12			6.00	0.30	6.0						7.90	7.80	3.0
14	3.30			0.23			6.00	0.30	6.0						7.90	7.80	3.0
15	1.60			0.14			6.00	0.30	6.0						7.90	7.90	4.0
16	3.20			0.21			6.00	0.30	6.0						7.90	7.90	3.0
17	3.00			0.20			6.00	0.30	6.0						7.90	7.70	5.0
18	1.30			0.09			6.00	0.30	6.0						7.70	7.90	3.5
19	1.60			0.04			12.00	0.80	34.0								2.5
20	4.10			0.21			12.00	0.80	34.0						8.00	7.90	2.5
21	3.80			0.23			12.00	0.80	34.0						7.90	7.90	4.0
22	4.70			0.17			12.00	0.80	34.0						7.90	7.90	4.0
23	2.90			0.46			12.00	0.80	34.0						7.70	7.90	2.5
24	8.90			0.52			12.00	0.80	34.0						7.70	7.90	1.5
25	2.30			0.41			12.00	0.80	34.0						7.70	7.90	2.0
26	1.60			0.33			12.00	0.80	34.0						7.90	7.80	1.0
27	3.20			0.28			12.00	0.80	34.0						7.90	7.80	0.5
28	2.00			0.34			12.00	0.80	34.0						7.90	7.80	0.5
29	1.70			0.33			12.00	0.80	34.0						7.90	7.70	2.0
30	3.10			0.35			12.00	0.80	34.0						7.80	7.70	2.0
31	1.90			0.41			12.00	0.80	34.0						7.90	7.70	0.5
MAX	8.90			0.52			12.00	0.80	34.0						8.00	7.90	5.0
MIN	1.30			0.04			6.00	0.30	6.0						7.70	7.70	0.50
AVG	2.68			0.23			8.52	0.51	17.7						7.87	7.84	3.2

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1987

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	50.00			0.18			30.00	0.45	6.0								3.5
2	23.00			0.21			30.00	0.45	6.0								3.0
3	12.10			0.20			12.00	0.23	6.0								2.8
4	17.50			0.19			12.00	0.23	6.0								3.0
5	197.00			0.13			12.00	0.23	6.0								3.5
6	88.00			0.19			40.00	0.88	6.0								3.0
7	60.00			0.20			20.00	0.45	6.0								3.5
8	20.00			0.19			20.00	0.45	6.0								3.0
9	17.00			0.21			20.00	0.45	6.0								4.0
10	9.60			0.18			20.00	0.45	6.0								4.0
11	20.00			0.16			20.00	0.45	6.0								4.5
12	35.00			0.17			20.00	0.45	6.0								5.5
13	32.00			0.27			25.00	0.20	6.0								4.5
14	24.00			0.19			30.00	0.35	6.0								5.0
15	27.00			0.09			30.00	0.35	6.0								5.5
16	26.00			0.19			30.00	0.35	6.0								6.0
17	30.00			0.11			30.00	0.35	6.0								6.5
18	16.40			0.14			30.00	0.35	6.0								6.5
19	18.10			0.19			30.00	0.35	6.0								7.0
20	14.80			0.19			23.00	0.25	6.0								6.5
21	10.90			0.13			10.00	0.23	6.0								7.0
22	12.40			0.20			10.00	0.23	6.0								6.5
23	15.10			0.21			10.00	0.23	6.0								7.5
24	12.30			0.11			10.00	0.23	6.0						7.90	6.90	7.0
25	24.00			0.14			10.00	0.23	6.0								7.0
26	22.00			0.18			10.00	0.23	6.0								7.5
27	13.90			0.17			10.00	0.23	6.0								7.5
28	11.70			0.17			10.00	0.23	6.0								7.5
29	12.30			0.13			10.00	0.23	6.0								7.0
30	10.00			0.17			10.00	0.23	6.0								7.0
MAX	197.00			0.27			40.00	0.88	6.00						7.90	6.90	7.5
MIN	9.60			0.09			10.00	0.20	6.00						7.90	6.90	2.8
AVG	29.40			0.17			19.47	0.33	6.00						7.90	6.90	5.4

WATER PLANT OPTIMIZATION STUDY

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1987

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. A10	(1) (PAC)	(2)	(3)	(4)	METAL RES. Al/Fe (mg/L)		pH		TEMP DEG. C.
	Raw	Set.	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	
1	3.90			0.17			6.00	0.25	6.0						7.90	7.30	18.5
2				0.10			6.00	0.25	6.0						7.90	7.30	18.5
3	3.00			0.05			6.00	0.25	6.0								19.0
4	3.20			0.06			6.00	0.25	6.0								19.5
5	4.80			0.05			6.00	0.25	6.0						7.80	7.40	19.0
6	4.00			0.04			6.00	0.25	6.0						7.70	7.10	19.5
7	3.20			0.07			6.00	0.25	6.0						8.00	7.20	19.0
8	3.80			0.03			6.00	0.25	6.0								21.0
9	4.10			0.02			6.00	0.25	6.0								21.0
10	2.30			0.01			1.50	0.25	6.0						8.10	7.40	20.5
11	2.90			0.02			1.50	0.25	6.0								21.5
12	2.20			0.02			1.50	0.25	6.0								21.5
13	3.60			0.02			1.50	0.25	6.0								21.5
14	4.30			0.03			1.50	0.25	6.0						7.80	7.40	20.5
15	6.20			0.03			1.50	0.25	6.0								20.0
16	4.30			0.02			1.50	0.25	6.0								20.5
17	4.30			0.04			1.50	0.25	6.0						7.90	7.30	20.5
18	3.00			0.03			1.50	0.25	6.0								21.5
19	2.90			0.02			1.50	0.25	6.0								21.0
20	5.00			0.04			1.50	0.25	6.0						8.00	7.50	21.5
21	2.70			0.05			1.50	0.25	6.0								22.0
22	3.50			0.07			1.50	0.25	6.0								22.0
23	4.20						1.50	0.25	6.0								22.5
24	2.80			0.09			1.50	0.25	6.0								23.0
25	3.00			0.07			1.50	0.25	6.0						7.80	7.50	23.5
26	3.60			0.05			1.50	0.25	6.0								23.5
27	3.10			0.11			1.50	0.25	6.0								23.0
28	3.00			0.26			1.50	0.25	6.0								23.5
29	3.40			0.15			1.50	0.25	6.0								23.5
30	3.40			0.17			1.50	0.25	6.0								24.0
31	3.90			0.15			1.50	0.25	6.0								24.0
MAX	6.20			0.26			6.00	0.25	6.00						8.10	7.50	24.0
MIN	2.20			0.01			1.50	0.25	6.00						7.70	7.10	18.5
AVG	3.59			0.07			2.81	0.25	6.00						7.89	7.34	21.3

NOTES FOR TABLE 2.1 PARTICULATE REMOVAL PROFILE

The general comments listed for Table 2.0 Particulate Removal Summary are also applicable to this table.

WATER PLANT OPTIMIZATION STUDY

TABLE 3.0: DISINFECTION SUMMARY

	CHEMICAL	1987						1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	Cl_2 Demand																								
	Cl_2 Dosage mg/L			1.2			0.17			0.6			0.04			1.6						1.3			0.06
	Ammonia																								
	SO_2																								
	Resid. Cl_2 Free				1.20	0.80	1.00				1.10	0.50	0.82				1.50	0.60	1.01				0.60	0.20	0.50
	Resid. Cl_2 Comb.						0.20						0.20						0.30						0.20
	Resid. Cl_2 Total				1.50	1.00	1.17				1.50	0.80	0.98				2.00	0.80	1.29				0.80	0.60	0.70
	F-Dosage																								
	F-Res.																								
FEB	Cl_2 Demand																								
	Cl_2 Dosage mg/L			1.4			0.10			1.1			0.04			1.7			0.10			1.2			0.15
	Ammonia																								
	SO_2																								
	Resid. Cl_2 Free				1.10	0.70	0.92				0.80	0.50	0.66				1.50	0.80	1.09				0.80	0.50	0.60
	Resid. Cl_2 Comb.						0.10						0.10						0.20						0.00
	Resid. Cl_2 Total				1.30	0.80	1.05				1.00	0.60	0.80				1.50	1.00	1.28				1.00	0.40	0.60
	F-Dosage																								
	F-Res.																								
MAR	Cl_2 Demand																								
	Cl_2 Dosage mg/L			1.2			0.09			1.5			0.04			1.7			0.14			1.1			0.13
	Ammonia																								
	SO_2																								
	Resid. Cl_2 Free				1.00	0.40	0.75				1.00	0.60	0.78				1.50	0.70	1.20				0.80	0.40	0.50
	Resid. Cl_2 Comb.						0.20						0.20						0.20						0.10
	Resid. Cl_2 Total				1.10	0.70	0.93				1.20	0.70	0.97				2.00	1.00	1.38				0.80	0.60	0.70
	F-Dosage																								
	F-Res.																								

TABLE 3.0: DISINFECTION SUMMARY (CONT'D)

	CHEMICAL	1987						1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
APR	Cl2 Demand																								
	Cl2 Dosage mg/L			1.2			0.10			1.2			0.08			1.6			0.09			1.2			0.09
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				1.00	0.60	0.85				1.00	0.60	0.78				1.50	0.80	1.06				0.60	0.40	0.50
	Resid. Cl2 Comb.						0.20						0.20						0.20						0.20
	Resid. Cl2 Total				1.10	0.80	1.03				1.20	0.70	0.96				2.00	0.80	1.24				0.80	0.60	0.70
	F-Dosage																								
	F-Res.																								
MAY	Cl2 Demand																								
	Cl2 Dosage mg/L			1.1			0.08			1.3			0.03			1.7			0.04			1.4			0.08
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				1.10	0.40	0.79				1.10	0.40	0.75				1.30	0.60	0.85				0.80	0.40	0.70
	Resid. Cl2 Comb.						0.10						0.02						0.20						0.10
	Resid. Cl2 Total				1.10	0.60	0.92				1.20	0.60	0.97				1.50	0.60	0.91				1.20	0.60	0.80
	F-Dosage																								
	F-Res.																								
JUN	Cl2 Demand																								
	Cl2 Dosage mg/L			1.0			0.43			1.2			0.12			1.6			0.04			1.2			0.11
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				1.00	0.40	0.69				1.00	0.30	0.66				1.00	0.60	0.77				0.80	0.20	0.60
	Resid. Cl2 Comb.						0.20						0.20						0.10						0.20
	Resid. Cl2 Total				1.10	0.60	0.84				1.20	0.50	0.81				1.50	0.60	0.83				1.00	0.20	0.80
	F-Dosage																								
	F-Res.																								

TABLE 3.0: DISINFECTION SUMMARY (CONT'D)

	CHEMICAL	1987						1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JUL	Cl2 Demand																								
	Cl2 Dosage mg/L			0.9			0.20			1.3			0.17			1.5			0.03			2.0			0.15
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				1.10	0.20	0.62				0.70	0.20	0.47				1.00	0.20	0.59				1.20	0.30	0.70
	Resid. Cl2 Comb.						0.20						0.30						0.20						0.10
	Resid. Cl2 Total				1.10	0.40	0.80				1.00	0.50	0.75				1.00	0.60	0.75				1.00	0.40	0.80
	F-Dosage																								
	F-Res.																								
AUG	Cl2 Demand																								
	Cl2 Dosage mg/L			1.1			0.29			1.3			0.05			1.5			0.05			1.5			0.07
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				0.90	0.40	0.72				1.00	0.20	0.45				0.80	0.40	0.58				1.20	0.20	0.50
	Resid. Cl2 Comb.						0.10						0.20						0.30						0.30
	Resid. Cl2 Total				1.10	0.60	0.85				1.00	0.40	0.65				1.00	0.60	0.83				1.00	0.60	0.80
	F-Dosage																								
	F-Res.																								
SEP	Cl2 Demand																								
	Cl2 Dosage mg/L			1.0			0.21			1.3			0.15			1.8			0.08			1.8			0.12
	Ammonia																								
	SO2																								
	Resid. Cl2 Free				1.00	0.30	0.71				0.80	0.30	0.46				1.00	0.40	0.74				1.30	0.60	0.80
	Resid. Cl2 Comb.						0.20						0.20						0.20						0.20
	Resid. Cl2 Total				1.10	0.50	0.86				1.00	0.40	0.63				2.00	0.60	0.96				1.00	0.30	1.00
	F-Dosage																								
	F-Res.																								

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TABLE 3.0: DISINFECTION SUMMARY (CONT'D)

	CHEMICAL	1987						1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
OCT	Cl2 Demand																								
	Cl2 Dosage mg/L									1.6			0.04			1.9									0.07
	Ammonia																								
	SO2																								
	Resid. Cl2 Free										1.00	0.30	0.70				2.00	0.40	0.80				1.10	0.60	0.08
	Resid. Cl2 Comb.												0.20						0.20						0.10
	Resid. Cl2 Total										1.10	0.50	0.91				2.10	0.60	0.97				1.50	0.80	0.90
	F-Dosage																								
	F-Res.																								
NOV	Cl2 Demand																								
	Cl2 Dosage mg/L									1.5			0.19			1.5			0.05			1.7			0.09
	Ammonia																								
	SO2																								
	Resid. Cl2 Free										1.50	0.50	0.86				1.10	0.40	0.68				1.50	0.40	0.80
	Resid. Cl2 Comb.												0.20						0.20						0.10
	Resid. Cl2 Total										2.00	0.60	1.07				1.50	0.20	0.84				1.50	0.60	0.90
	F-Dosage																								
	F-Res.																								
DEC	Cl2 Demand																								
	Cl2 Dosage mg/L									1.3			0.18			1.6			0.07			1.7			0.13
	Ammonia																								
	SO2																								
	Resid. Cl2 Free										1.20	0.80	0.93				1.50	0.60	1.06				1.50	0.60	0.90
	Resid. Cl2 Comb.												0.20						0.30						0.20
	Resid. Cl2 Total										1.50	1.00	1.09				2.00	0.90	1.38				2.00	0.80	1.10
	F-Dosage																								
	F-Res.																								

NOTES FOR TABLE 3.0 DISINFECTION SUMMARY

Table 3.0 documents the chlorine disinfectant dosage and residuals as recorded daily in the plant log. Chlorine dosage is reported in mg/L of active chlorine. The source of chlorine is calcium hypochlorite which contains 65 percent active chlorine.

For 1986 and 1987, the dosage rate is recorded in mg/L. Prior to 1986 only the mass weight of chemical was recorded each time it was added. To determine the average feed rate for the month, the total amount by weight of chemical added is multiplied by 65 percent to reflect the amount of active chlorine. For pre-chlorination this is divided by the quantity of raw water pumped and for post chlorination this is divided by the quantity of treated water pumped. This calculation is approximate and does not account for the amount of solution stored in the tank at the beginning and end of the month.

The post-chlorination data for January 1985 and October 1985 is not available. It is assumed that the information was not recorded on the log sheets for these months.

Free and total residual chlorine levels are measured for treated water only. The combined residual is calculated as the difference between the total and free residual.

In some cases, the value of the free residual chlorine recorded in the daily log is greater than the corresponding value of the total chlorine. The values are documented in the report as recorded in the log sheets, but it is probable that these values were originally recorded in the wrong columns.

TABLE 3.1: DISINFECTION PROFILE JANUARY 1984

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.2	0.6	0.8			1
2												0.4	0.4	0.8			2
3												0.4	0.4	0.8			3
4												0.6	0.0	0.6			4
5												0.4	0.4	0.8			5
6												0.4	0.2	0.6			6
7												0.4	0.2	0.6			7
8												0.4	0.2	0.6			8
9												0.4	0.2	0.6			9
10												0.6	0.0	0.6			10
11												0.6	0.2	0.8			11
12												0.6	0.2	0.8			12
13												0.6	0.2	0.8			13
14												0.6	0.2	0.8			14
15												0.6	0.2	0.8			15
16												0.6	0.0	0.6			16
17												0.6	0.0	0.6			17
18												0.6	0.0	0.6			18
19												0.6	0.0	0.6			19
20												0.6	0.2	0.8			20
21												0.6	0.2	0.8			21
22												0.6	0.2	0.8			22
23												0.2	0.4	0.6			23
24												0.6	0.0	0.6			24
25												0.6	0.0	0.6			25
26												0.6	0.0	0.6			26
27												0.6	0.0	0.6			27
28												0.6	0.0	0.6			28
29												0.6	0.0	0.6			29
30												0.6	0.0	0.6			30
31												0.6	0.0	0.6			31
MAX												0.6	0.6	0.8			
MIN												0.2	0.0	0.6			
AVG		1.32							0.06			0.5	0.1	0.7			

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TABLE 3.1: DISINFECTION PROFILE APRIL 1984

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.4					1
2												0.4	0.2	0.6			2
3												0.6	0.0	0.6			3
4												0.4	0.2	0.6			4
5												0.6	0.0	0.6			5
6												0.6	0.0	0.6			6
7												0.6	0.0	0.6			7
8												0.4	0.2	0.6			8
9												0.6	0.0	0.6			9
10												0.4	0.2	0.6			10
11												0.4	0.2	0.6			11
12												0.4	0.2	0.6			12
13												0.4	0.2	0.6			13
14												0.4	0.2	0.6			14
15												0.4	0.2	0.6			15
16												0.4	0.2	0.6			16
17												0.4	0.4	0.8			17
18												0.6	0.2	0.8			18
19												0.6	0.2	0.8			19
20												0.4	0.4	0.8			20
21												0.6	0.2	0.8			21
22												0.6	0.2	0.8			22
23												0.6	0.2	0.8			23
24												0.6	0.2	0.8			24
25												0.6	0.2	0.8			25
26												0.6	0.2	0.8			26
27												0.6	0.2	0.8			27
28												0.6	0.2	0.8			28
29												0.6	0.2	0.8			29
30												0.6	0.2	0.8			30
MAX												0.6	0.4	0.8			
MIN												0.0	0.0	0.0			
AVG		1.24							0.09			0.5	0.2	0.7			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JULY 1984

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.6	0.4	1.0			1
2												0.6	0.4	1.0			2
3												0.8	0.2	1.0			3
4												0.8	0.2	1.0			4
5												0.8	0.2	1.0			5
6												0.6	0.4	1.0			6
7												0.6	0.4	1.0			7
8												0.6		0.4			8
9												0.5	0.3	0.8			9
10												0.6	0.0	0.6			10
11												0.3	0.3	0.6			11
12												0.6	0.2	0.8			12
13												0.8	0.0	0.8			13
14												0.8	0.0	0.8			14
15												0.8	0.0	0.8			15
16												1.0		0.7			16
17												1.0		0.7			17
18												1.0		0.8			18
19												1.0		0.7			19
20												1.2		0.8			20
21												0.8	0.0	0.8			21
22												0.8	0.0	0.8			22
23												0.8		0.6			23
24												0.6	0.0	0.6			24
25												0.6	0.2	0.8			25
26												0.6	0.2	0.8			26
27												0.8	0.0	0.8			27
28												0.8	0.0	0.8			28
29												0.8	0.0	0.8			29
30												0.8		0.6			30
31												0.8	0.0	0.8			31
MAX												1.2	0.4	1.0			
MIN												0.3	0.0	0.4			
AVG		1.97							0.15			0.7	0.1	0.8			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE OCTOBER 1984

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.6	0.2	0.8			1
2												0.7	0.1	0.8			2
3												0.7	0.1	0.8			3
4												0.7	0.1	0.8			4
5												0.7	0.3	1.0			5
6												0.7	0.3	1.0			6
7												0.7	0.3	1.0			7
8												1.1	0.4	1.5			8
9												0.8	0.2	1.0			9
10												0.8	0.2	1.0			10
11												0.8	0.2	1.0			11
12												1.1		1.0			12
13												1.1		1.0			13
14												1.1		1.0			14
15												1.0	0.0	1.0			15
16												0.8	0.2	1.0			16
17												0.8	0.2	1.0			17
18												0.8	0.1	0.9			18
19												0.8	0.0	0.8			19
20												0.8	0.0	0.8			20
21												0.8	0.0	0.8			21
22												0.8	0.2	1.0			22
23												0.6	0.2	0.8			23
24												0.8	0.1	0.9			24
25												0.6	0.2	0.8			25
26												0.8	0.2	1.0			26
27												0.8	0.2	1.0			27
28												0.8	0.2	1.0			28
29												0.8	0.1	0.9			29
30												0.8	0.2	1.0			30
31												0.6	0.2	0.8			31
MAX												1.1	0.4	1.5			
MIN												0.6	0.0	0.8			
AVG									0.07			0.8	0.2	0.9			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JANUARY 1985

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Oem.	Dos.			Free	Comb.	Total	Oem.	Dos.			Free	Comb.	Total			
1												1.5	0.5	2.0			1
2												1.0	0.2	1.2			2
3												1.2	0.3	1.5			3
4												1.0	0.5	1.5			4
5												1.0	0.5	1.5			5
6												1.0	0.5	1.5			6
7												1.1	0.4	1.5			7
8												1.1	0.4	1.5			8
9												1.0	0.2	1.2			9
10												1.0	0.1	1.1			10
11												0.9	0.2	1.1			11
12												1.0	0.5	1.5			12
13												1.0	0.5	1.5			13
14												0.8	0.2	1.0			14
15												0.8	0.2	1.0			15
16												0.8	0.2	1.0			16
17												0.8	0.2	1.0			17
18												0.8	0.2	1.0			18
19												1.0	0.0	1.0			19
20												1.0	0.0	1.0			20
21												0.6	0.2	0.8			21
22												0.8	0.0	0.8			22
23												0.6	0.2	0.8			23
24												1.0	0.5	1.5			24
25												1.0	0.5	1.5			25
26												1.0	0.5	1.5			26
27												1.0	0.5	1.5			27
28												1.5	0.0	1.5			28
29												1.5	0.0	1.5			29
30												1.2	0.3	1.5			30
31												1.2	0.3	1.5			31
MAX												1.5	0.5	2.0			
MIN												0.6	0.0	0.8			
AVG		2.40							0.00			1.0	0.3	1.3			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE APRIL 1985

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												1.0	0.2	1.2			1
2												1.0	0.2	1.2			2
3												0.9	0.1	1.0			3
4												0.9	0.1	1.0			4
5												0.9	0.1	1.0			5
6												0.8	0.4	1.2			6
7												1.5		1.2			7
8												1.0	0.2	1.2			8
9												0.9	0.1	1.0			9
10												0.9	0.1	1.0			10
11												0.9	0.1	1.0			11
12												0.9	0.1	1.0			12
13												0.9	0.1	1.0			13
14												1.0	0.0	1.0			14
15												1.0	0.2	1.2			15
16												1.1	0.1	1.2			16
17												0.8	0.0	0.8			17
18												0.8	1.2	2.0			18
19												1.2	0.3	1.5			19
20												1.2	0.3	1.5			20
21												1.2	0.3	1.5			21
22												1.1	0.9	2.0			22
23												1.0	0.5	1.5			23
24												1.0	0.2	1.2			24
25												1.5		1.2			25
26												1.2	0.0	1.2			26
27												1.2	0.0	1.2			27
28												1.2	0.0	1.2			28
29												1.5	0.0	1.5			29
30												1.2	0.3	1.5			30
MAX												1.5	1.2	2.0			
MIN												0.8	0.0	0.8			
AVG		2.50							0.13			1.1	0.2	1.2			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JULY 1985

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.6	0.2	0.8			1
2												0.6	0.4	1.0			2
3												0.6	0.4	1.0			3
4												0.6	0.2	0.8			4
5												0.6	0.2	0.8			5
6												0.6	0.0	0.6			6
7												0.6	0.0	0.6			7
8												0.6	0.0	0.6			8
9												0.4	0.2	0.6			9
10												0.4	0.2	0.6			10
11												0.6	0.0	0.6			11
12													0.0				12
13												0.6	0.4	1.0			13
14												0.6	0.0	0.6			14
15												0.6	0.0	0.6			15
16												0.6	0.0	0.6			16
17												0.6	0.0	0.6			17
18												0.4	0.2	0.6			18
19												0.2	0.4	0.6			19
20												0.6	0.2	0.8			20
21												1.0		0.8			21
22												0.8	0.2	1.0			22
23												0.8	0.2	1.0			23
24												0.6	0.2	0.8			24
25												0.6	0.4	1.0			25
26												0.6	0.4	1.0			26
27												0.6	0.0	0.6			27
28												0.6	0.0	0.6			28
29												0.6	0.0	0.6			29
30												0.6	0.2	0.8			30
31												0.6	0.2	0.8			31
MAX												1.0	0.4	1.0			
MIN												0.2	0.0	0.6			
AVG		2.30							0.05			0.6	0.2	0.7			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE OCTOBER 1985

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												1.0					1
2												0.6	0.2	0.8			2
3												0.4	0.2	0.6			3
4												0.8	0.3	1.1			4
5												0.6	0.4	1.0			5
6												0.6	0.4	1.0			6
7												0.6	0.4	1.0			7
8												1.0	0.0	1.0			8
9												0.6	0.4	1.0			9
10												1.0	0.0	1.0			10
11												1.0	0.1	1.1			11
12												0.6	0.5	1.1			12
13												1.0	0.1	1.1			13
14												2.0	0.1	2.1			14
15												1.5		1.0			15
16												1.0	0.5	1.5			16
17												1.0	0.0	1.0			17
18												1.2	0.3	1.5			18
19												0.6	0.2	0.8			19
20												0.6	0.0	0.6			20
21												0.7	0.0	0.7			21
22												0.7	0.3	1.0			22
23												0.6	0.0	0.6			23
24												0.6	0.4	1.0			24
25												0.6	0.4	1.0			25
26												0.6	0.4	1.0			26
27												0.6	0.2	0.8			27
28												0.6	0.0	0.6			28
29												0.6	0.0	0.6			29
30												0.6	0.0	0.6			30
31												0.7	0.3	1.0			31
MAX												2.0	0.5	2.1			
MIN												0.4	0.0	0.6			
AVG		2.80										0.8	0.2	1.0			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JANUARY 1986

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												1.5	0.0	1.5			1
2												1.0	0.2	1.2			2
3												1.0	0.2	1.2			3
4												1.0	0.0	1.0			4
5												1.0	0.0	1.0			5
6												0.5	0.5	1.0			6
7												0.9	0.0	0.9			7
8												0.6	0.2	0.8			8
9												0.9		0.8			9
10												0.8	0.2	1.0			10
11												0.8	0.2	1.0			11
12												0.8	0.2	1.0			12
13												0.8	0.2	1.0			13
14												0.8	0.0	0.8			14
15												0.8	0.2	1.0			15
16												0.8	0.2	1.0			16
17												0.8	0.2	1.0			17
18												0.8	0.2	1.0			18
19												0.8	0.4	1.2			19
20												0.8	0.2	1.0			20
21												0.6	0.2	0.8			21
22												0.7	0.1	0.8			22
23												0.8	0.0	0.8			23
24												0.9		0.8			24
25												0.6	0.2	0.8			25
26												0.6	0.4	1.0			26
27												0.8	0.2	1.0			27
28												0.8	0.2	1.0			28
29												0.8	0.2	1.0			29
30												0.8	0.2	1.0			30
31												0.8	0.2	1.0			31
MAX												1.5	0.5	1.5			
MIN												0.5	0.0	0.8			
AVG		0.58							0.04			0.8	0.2	1.0			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE   APRIL 1986

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												1.0	0.0	1.0			1
2												1.0	0.0	1.0			2
3												1.0		0.8			3
4												1.0	0.0	1.0			4
5												0.8	0.2	1.0			5
6													0.0				6
7												0.8	0.2	1.0			7
8												0.8	0.2	1.0			8
9												0.8	0.2	1.0			9
10												0.8	0.4	1.2			10
11												0.8	0.4	1.2			11
12												0.8	0.2	1.0			12
13												0.8	0.3	1.1			13
14												0.8	0.2	1.0			14
15												0.8	0.2	1.0			15
16												0.8	0.2	1.0			16
17												0.8	0.2	1.0			17
18												0.8	0.3	1.1			18
19												0.8	0.2	1.0			19
20												0.8	0.2	1.0			20
21												0.8	0.2	1.0			21
22												0.8	0.0	0.8			22
23												0.6	0.1	0.7			23
24												0.6	0.2	0.8			24
25												0.6	0.2	0.8			25
26												0.6	0.2	0.8			26
27												0.8	0.2	1.0			27
28												0.6	0.2	0.8			28
29												0.7	0.1	0.8			29
30												0.6	0.2	0.8			30
MAX												1.0	0.4	1.2			
MIN												0.6	0.0	0.7			
AVG		1.24							0.08			0.7	0.2	0.9			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JULY 1986

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.7	0.1	0.8			1
2												0.5	0.3	0.8			2
3												0.6	0.2	0.8			3
4												0.4	0.4	0.8			4
5												0.4	0.4	0.8			5
6												0.4	0.3	0.7			6
7												0.4	0.3	0.7			7
8												0.2	0.4	0.6			8
9												0.3	0.4	0.7			9
10												0.6	0.4	1.0			10
11												0.5	0.5	1.0			11
12												0.4	0.3	0.7			12
13												0.5	0.3	0.8			13
14												0.5	0.3	0.8			14
15												0.6	0.1	0.7			15
16												0.7	0.2	0.9			16
17												0.5	0.2	0.7			17
18												0.4	0.4	0.8			18
19												0.5	0.3	0.8			19
20												0.4	0.4	0.8			20
21												0.7	0.1	0.8			21
22												0.4	0.3	0.7			22
23												0.4	0.3	0.7			23
24												0.6	0.2	0.8			24
25												0.5	0.2	0.7			25
26												0.4	0.1	0.5			26
27												0.5	0.2	0.7			27
28												0.5	0.3	0.8			28
29												0.5	0.2	0.7			29
30												0.4	0.3	0.7			30
31												0.3	0.2	0.5			31
MAX												0.7	0.5	1.0			
MIN												0.2	0.1	0.5			
AVG		1.30							0.17			0.5	0.3	0.8			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE OCTOBER 1986

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.5	0.2	0.7			1
2												0.7	0.1	0.8			2
3												0.8	0.3	1.1			3
4												0.7	0.3	1.0			4
5												0.5	0.4	0.9			5
6												0.7	0.3	1.0			6
7												1.0	0.1	1.1			7
8												0.8	0.2	1.0			8
9												0.7	0.1	0.8			9
10												0.7	0.3	1.0			10
11												0.8	0.2	1.0			11
12												0.7	0.3	1.0			12
13												0.5	0.3	0.8			13
14												0.5	0.2	0.7			14
15												0.7	0.1	0.8			15
16												0.3	0.2	0.5			16
17												0.5	0.1	0.6			17
18												0.7	0.3	1.0			18
19												0.8	0.2	1.0			19
20												1.0	0.1	1.1			20
21												0.8	0.2	1.0			21
22												0.8	0.2	1.0			22
23												0.8	0.2	1.0			23
24												0.8	0.2	1.0			24
25												0.7	0.1	0.8			25
26												0.6	0.2	0.8			26
27												0.8	0.2	1.0			27
28												0.8	0.2	1.0			28
29												0.8	0.2	1.0			29
30												0.6	0.2	0.8			30
31												0.7	0.1	0.8			31
MAX												1.0	0.4	1.1			
MIN												0.3	0.1	0.5			
AVG		1.56							0.04			0.7	0.2	0.9			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JANUARY 1987

DATE	PRE-CHLORINATION: Cl2 (mg/L) Dem.	Cl2 (mg/L) Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb.	Total	POST-CHLORINATION: Cl2 (mg/L) Dem.	Cl2 (mg/L) Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb.	Total	FLUORIDE Dos.	FLUORIDE Res.	DATE
1												0.8	0.2	1.0			1
2												0.8	0.2	1.0			2
3												0.8	0.2	1.0			3
4												0.8	0.2	1.0			4
5												1.0	0.0	1.0			5
6												1.0	0.0	1.0			6
7												1.0	0.0	1.0			7
8												1.0	0.1	1.1			8
9												0.8	0.2	1.0			9
10												1.0	0.5	1.5			10
11												1.2	0.3	1.5			11
12												1.0	0.0	1.0			12
13												1.0	0.0	1.0			13
14												1.0	0.0	1.0			14
15												0.8	0.4	1.2			15
16												1.0	0.2	1.2			16
17												1.0	0.2	1.2			17
18												1.2	0.3	1.5			18
19												1.0	0.0	1.0			19
20												1.0	0.0	1.0			20
21												0.9	0.3	1.2			21
22												1.2	0.3	1.5			22
23												1.0	0.2	1.2			23
24												1.0	0.5	1.5			24
25												1.2	0.3	1.5			25
26												1.0	0.0	1.0			26
27												1.0	0.0	1.0			27
28												1.0	0.0	1.0			28
29												1.1	0.1	1.2			29
30												1.2	0.3	1.5			30
31												1.2	0.3	1.5			31
MAX												1.2	0.5	1.5			
MIN												0.8	0.0	1.0			
AVG		1.16							0.17			1.0	0.2	1.2			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE APRIL 1987

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												1.0	0.1	1.1			1
2												0.8	0.2	1.0			2
3												0.7	0.2	0.9			3
4												0.8	0.2	1.0			4
5												0.9	0.2	1.1			5
6												1.0	0.1	1.1			6
7												1.0	0.1	1.1			7
8												1.0	0.1	1.1			8
9												0.8	0.2	1.0			9
10												0.8	0.2	1.0			10
11												0.9	0.2	1.1			11
12												0.8	0.2	1.0			12
13												0.8	0.3	1.1			13
14												1.0	0.1	1.1			14
15												0.8	0.2	1.0			15
16												0.7	0.3	1.0			16
17												1.0	0.1	1.1			17
18												1.0	0.1	1.1			18
19												0.9	0.2	1.1			19
20												1.0	0.1	1.1			20
21												1.0	0.1	1.1			21
22												0.8	0.2	1.0			22
23												0.6	0.2	0.8			23
24												0.6	0.2	0.8			24
25												0.7	0.1	0.8			25
26												0.8	0.3	1.1			26
27												0.8	0.3	1.1			27
28												1.0	0.1	1.1			28
29												1.0	0.1	1.1			29
30												0.6	0.2	0.8			30
MAX												1.0	0.3	1.1			
MIN												0.6	0.1	0.8			
AVG		1.19							0.10			0.9	0.2	1.0			

WATER PLANT OPTIMIZATION STUDY

TABLE 3.1: DISINFECTION PROFILE JULY 1987

DATE	PRE-CHLORINATION							POST-CHLORINATION							FLUORIDE		DATE
	Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Cl2 (mg/L)		NH3	SO2	RESIDUAL Cl2			Dos.	Res.	
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total			
1												0.9	0.2	1.1			1
2												0.8	0.2	1.0			2
3												0.8	0.2	1.0			3
4												0.8	0.3	1.1			4
5													0.0				5
6												0.8	0.2	1.0			6
7												0.4	0.1	0.5			7
8												0.4	0.1	0.5			8
9												0.3	0.1	0.4			9
10												0.4	0.2	0.6			10
11												0.2	0.2	0.4			11
12												0.3	0.2	0.5			12
13												0.2	0.2	0.4			13
14												0.4	0.1	0.5			14
15												0.8	0.2	1.0			15
16												0.6	0.1	0.7			16
17												1.1	0.0	1.1			17
18												0.7	0.1	0.8			18
19												0.5	0.2	0.7			19
20												0.8	0.2	1.0			20
21												0.6	0.2	0.8			21
22												0.7	0.2	0.9			22
23												0.6	0.2	0.8			23
24												0.6	0.2	0.8			24
25												0.7	0.2	0.9			25
26												0.5	0.2	0.7			26
27												0.7	0.1	0.8			27
28												0.3	0.5	0.8			28
29												0.9	0.2	1.1			29
30												0.9	0.2	1.1			30
31												0.9	0.1	1.0			31
MAX												1.1	0.5	1.1			
MIN												0.2	0.0	0.4			
AVG		0.92							0.20			0.6	0.2	0.8			

NOTES FOR TABLE 3.1 DISINFECTION PROFILE

The general comments listed for Table 3.0 Disinfection Summary are also applicable to this table.

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
GENERAL	ALKALINITY	R	85.4	80.6	83.28	83.80	79.60	80.90				0.20		
	mg/L	T	79.7	70.2	74.96	75.6	70.4	71.74						
	AMMONIUM TOTAL	R	0.032	0.016	0.025	<W	<W	<W						
	mg/L	T	0.030	0.014	0.022	<W	<W	<W				0.05		
	CALCIUM	R	29	25.8	27.81	28.5	26.5	27.14				0.1		
	mg/L	T	29.3	26.9	28.31	28.2	27	27.73						
	CHLORIDE	R	10.9	7.7	9.35	9.6	7	8.29				0.2	250	
	mg/L	T	11.20	9.50	10.09	10.20	8.40	9.54						
	COLOUR	R	13.00	1.50	4.53	18.00	2.00	5.57				0.50	5.00	
	TCU	T	1.00	<W	0.50	0.50	W	W						
	CONDUCTIVITY	R	238	220	228	230	223	226				0.01		
	umho/cm	T	243	227	236	240	231	236						
	FIELD CHLORINE (COMB)	R	NA			NA	NA	NA						
	mg/L	T	0.4	0.1	0.16	0.5	0.2	0.35						
	FIELD CHLORINE (FREE)	R	NA			NA	NA	NA						
	mg/L	T	1	0.6	0.786	1.5	0.7	1.1						
	FIELD CHLORINE (TOTAL)	R	NA			NA	NA	NA						
	mg/L	T	1.2	0.8	0.82	2	0.9	1.2						
	FIELD pH	R	8.20	7.60	7.85	7.90	7.80	7.86						
		T	7.80	7.30	7.59	7.70	7.40	7.48						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
FIELD TEMPERATURE	R	18.50	0.50	4.40	4.50	3.00	3.50						
C	T	19.00	1.50	6.27	6.00	3.00	5.00						
FIELD TURBIDITY	R	20.1	1.6	7.39	17.1	1.8	6.68					1	
FTU	T	3.3	0.01	0.587	0.8	0.4	0.61						
FLUORIDE	R	0.11	0.08	0.10	0.10	0.07	0.08				0.01	2.40	
mg/L	T	0.10	0.06	0.08	0.08	0.05	0.07						
HARDNESS	R	104	86.5	99.4	103	95.4	97.77				0.5		
mg/L	T	104	96	101.2	102	97.3	99.41						
MAGNESIUM	R	7.80	4.85	7.28	7.70	7.10	7.28				0.05		
mg/L	T	7.75	7.05	7.43	7.60	7.15	7.32						
NITRATE	R				0.50	0.20	0.31				0.05	10.00	
mg/L	T				0.40	0.25	0.30						
NITRITE	R	0.010	0.001	0.005	0.010	<W					0.01	1.00	
mg/L	T	0.004	0.000	0.001	<W	<W							
NITROGEN TOTAL KJELDAHL	R	0.25	0.1	0.175	0.7	0.2	0.3				0.1	0.15	
mg/L	T	0.15	0.02	0.08	0.10	<W							
pH	R	8.33	7.98	8.15	8.19	8.06	8.12						
	T	8.18	7.28	7.69	7.83	7.33	7.52						
PHOSPHORUS FILTD REACTIVE	R	0.009	0.000	0.002	<W	<W					0.01		
mg/L	T	0.002	0.000	0.001	<W	<W							

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
	PHOSPHORUS TOTAL	R	0.027	0.004	0.011	0.020	0.010	0.017				0.01		
	mg/L	T	0.004	0.001	0.002	0.020	0.000	0.012						
	SODIUM	R	7.00	5.00	6.19	6.20	5.50	5.84				0.10		
	mg/L	T	7.50	5.60	6.34	6.50	5.50	5.96						
	TOTAL SOLIDS	R	162	128	147.6	150	145	147				1		
	mg/L	T	158	124	151.8	156	150	154						
	TURBIDITY	R	17.90	1.17	5.55	17.10	1.89	6.53				0.01	1.00	
	FTU	T	0.66	0.002	0.226	0.16	0.1	0.13						
METALS	ALUMINUM	R	0.57	0.024	0.105	0.3	0.021	0.119				0.003	0.1	
	mg/L	T	0.13	0.036	0.058	0.089	0.021	0.043						
	ARSENIC	R	<W	<W	<W	<W	<W	<W				0.00	0.05	
	mg/L	T	<W	<W	<W	<W	<W	<W						
	BARIUM	R	0.015	0.011	0.013	0.018	0.011	0.013				0.001	1.000	
	mg/L	T	0.016	0.011	0.013	0.016	0.011	0.012						
	BERYILIUM	R	<W	<W	<W	<W	<W	<W				0.001		
	mg/L	T	<W	<W	<W	<W	<W	<W						
	BORON	R	0.09	0.02	0.03	0.14	<W	0.07				0.02	5.00	
	mg/L	T	0.08	0.02	0.04	0.11	<W	0.05						
	CADMIUM	R	0.3	0.2	0.23	0.3	0.2	0.25				2	5	
	ug/L	T	0.3	0.2	0.23	0.3	0.2	0.25						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER			1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
CHROMUIM		R	0.002	0.001	0.001	0.002	<W	0.001				0.001	0.050	
	mg/L	T	0.002	0.001	0.001	0.001	<W	0.001						
COBALT		R	<W	<W	<W	0.002	<W	0.000				0.001		
	mg/L	T	<W	<W	<W	0.001	<W	0.000						
COPPER		R	0.007	0.001	0.003	0.007	<W	0.002				0.001	1.000	
	mg/L	T	0.006	0.001	0.004	0.010	0.003	0.005						
CYANIDE		R	<W	<W	<W	<W	<W	<W				0.001	0.2	
	mg/L	T	<W	<W	<W	<W	<W	<W						
IRON		R	0.500	0.027	0.123	0.41	0.035	0.149				0.002	0.3	
	mg/L	T	0.018	0.001	0.009	0.019	0.006	0.01						
LEAD		R	<W	<W	<W	<W	<W	<W				0.003	0.05	
	mg/L	T	<W	<W	<W	<W	<W	<W						
MANGANESE		R	0.010	0.002	0.004	0.008	<W	0.003				0.001	0.050	
	mg/L	T	0.002	0.001	0.001	0.002	0.001	0.001						
MOLYBDENUM		R	0.001	<W	0.001	0.001	<W	0.000				0.001		
	mg/L	T	0.001	<W	0.001	<W	0.00	0.001						
MERCURY		R	0.03	0.01	0.012	0.02	<W	0.007				0.01	1	
	ug/L	T	0.02	0.01	0.011	0.01	<W	0.002						
NICKEL		R	0.002	0.001	0.001	0.002	<W	0.000				0.002		
	mg/L	T	0.003	0.001	0.002	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
	SELENIUM	R	<W	<W	<W	<W	<W	<W				0.001	0.01	
	mg/L	T	<W	<W	<W	<W	<W	<W						
	STRONTIUM	R	0.110	0.086	0.094	0.120	0.083	0.096				0.001		
	mg/L	T	0.110	0.089	0.097	0.100	0.089	0.095						
	TIN	R												
		T												
	URANIUM	R	0.24	0.002	0.042	0.002	0.002	0.002				0.0001	0.02	
	mg/L	T	0.2	0.002	0.035	0.002	0.002	0.002						
PURGEABLES	VANADIUM	R	0.003	<W	0.001	0.001	0.001	0.001				0.0005	NONE	
	mg/L	T	0.002	<W	0.001	0.001	0.001	0.001						
	ZINC	R	0.009	0.001	0.003	0.006	0.003	0.004				0.0005	5	
	mg/L	T	0.006	0.001	0.003	0.007	0.004	0.005						
	BENZENE	R	5.00	<W	1.13	5.00	<W	1.00				0.05	10.00	
	ug/L	T	3.00	<W	0.92	4.00	<W	2.00						
	BROMOFORM	R	<W	<W	<W	<W	<W	<W				0.20	700.00	
	ug/L	T	<W	<W	<W	2.00	<W	0.33						
	CARBON TETRACHLORIDE	R	1.00	0.00	0.07	1.00	<W	0.43				0.20	3.00	
	ug/L	T	2.00	0.00	0.31	1	<W	0.5						
	CHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				0.1	100	
	ug/L	T	<W	<W	<W	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986			1985			1984			OWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
CHLORODIBROMOMETHANE	R	<W	<W	<W	<W	<W	<W				1.00	350.00	
ug/L	T	17.00	3	9.92	16.00	7.00	11.50						
CHLOROFORM	R	<W	<W	<W	<W	<W	<W				1.00	350.00	
ug/L	T	28.00	9.00	17.08	38.00	11.00	20.50						
1,2-DICHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				1.00	400.00	
ug/L	T	<W	<W	<W	<W	<W	<W						
1,3-DICHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				1.00	400.00	
ug/L	T	<W	<W	<W	<W	<W	<W						
1,4-DICHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				1.00	400.00	
ug/L	T	<W	<W	<W	<W	<W	<W						
DICHLOROBROMOMETHANE	R	<W	<W	<W	<W	<W	<W				1.00	350.00	
ug/L	T	13	6	9.3	16.00	7.00	10.67						
1,1-DICHLOROETHANE	R	<W	<W	<W	<W	<W	<W				1.00		
ug/L	T	<W	<W	<W	<W	<W	<W						
1,2-DICHLOROETHANE	R	<W	<W	<W	<W	<W	<W				1.00	10.00	
ug/L	T	<W	<W	<W	<W	<W	<W						
1,1-DICHLOROETHYLENE	R	<W	<W	<W	<W	<W	<W				1.00	0.30	
ug/L	T	<W	<W	<W	<W	<W	<W						
T,1,2-DICHLOROETHYLENE	R	<W	<W	<W	<W	<W	<W				1.00		
ug/L	T	<W	<W	<W	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
DICHLOROMETHANE	R												
ug/L	T												
1,2 DICHLOROPROPANE	R	<W	<W	<W	<W	<W	<W				1.00		
ug/L	T	<W	<W	<W	<W	<W	<W						
ETHYLBENZENE	R	8.00	<W	0.53	<W	<W	<W				1.00	1400	
ug/L	T	2.00	<W	0.15	<W	<W	<W						
ETHYLENE DIBROMIDE	R	<W	<W	<W									
ug/L	T	<W	<W	<W									
M-XYLENE	R	<W	<W	<W	<W	<W	<W				1.00	620	
ug/L	T	<W	<W	<W	<W	<W	<W						
O-XYLENE	R	<W	<W	<W	<W	<W	<W				0.05	620	
ug/L	T	<W	<W	<W	<W	<W	<W						
P-XYLENE	R	<W	<W	<W	<W	<W	<W				0.10	620	
ug/L	T	<W	<W	<W	<W	<W	<W						
TOLUENE	R	<W	<W	<W	<W	<W	<W				0.05	14300	
ug/L	T	2.00	<W	0.15	<W	<W	<W						
1,1,2,2-T-CHLOROETHANE	R	<W	<W	<W	<W	<W	<W				0.05	2	
ug/L	T	<W	<W	<W	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
	TETRACHLOROETHYLENE	R	<W	<W	<W							0.05	10	
	ug/L	T	<W	<W	<W									
	1,1,1-TRICHLOROETHANE	R	<W	<W	<W	<W	<W	<W						
	ug/L	T	<W	<W	<W	<W	<W	<W						
	1,1,2-TRICHLOROETHANE	R	<W	<W	<W	<W	<W	<W						
	ug/L	T	<W	<W	<W	<W	<W	<W						
	TRICHLOROETHYLENE	R	<W	<W	<W	<W	<W	<W						
	ug/L	T	<W	<W	<W	<W	<W	<W						
	TOTAL TRIHALOMETHANES	R	<W	<W	<W	<W	<W	<W				3.00	350	
	ug/L	T	47.00	23.00	36.30	65.00	25.00	43.00						
	TRIFLUOROCHLOROTOLUENE	R	<W	<W	<W	<W	<W	<W				1.00		
	ug/L	T	<W	<W	<W	<W	<W	<W						
ORGANO-	ALDRIN	R	<W	<W	<W	<W	<W	<W				1.00	700	
CHLORINES	ng/L	T	<W	<W	<W	<W	<W	<W						
	ALPHA BHC	R	6	1	2.857	4.00	<W	2.43				1.00	700	
	ng/L	T	5	1	2.18	4.00	2.00	3.00						
	ALPHA CHLORDANE	R	<W	<W	<W	<W	<W	<W				2.00	700	
	ng/L	T	<W	<W	<W	<W	<W	<W						
	BETA BHC	R	<W	<W	<W	1.00	<W	0.14				1.00	300	
	ng/L	T	<W	<W	<W	4.00	<W	0.57						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
DIELDRIN	R	<W	<W	<W	<W	<W	<W				2.00	700	
ng/L	T	<W	<W	<W	<W	<W	<W						
ENDRIN	R	<W	<W	<W	<W	<W	<W				4.00	200	
ng/L	T	<W	<W	<W	<W	<W	<W						
GAMMA CHLORDANE	R	<W	<W	<W	<W	<W	<W				2.00	700	
ng/L	T	<W	<W	<W	<W	<W	<W						
HEPTACHLOR EPOXIDE	R	<W	<W	<W	<W	<W	<W				1.00	3000	
ng/L	T	<W	<W	<W	<W	<W	<W						
HEPTACHLOR	R	<W	<W	<W	<W	<W	<W				1.00	3000	
ng/L	T	5.00	<W	0.45	4.00	<W	1.00						
HEXACHLOROBENZENE	R				32.00	<W	4.56				1.00	10	
ng/L	T				2.00	<W	0.29						
HEXACHLOROBUTADIENE	R	4	<W	0.929	38.00	<W	6.14						
ug/L	T	9.00	<W	2.45	9.00	<W	2.71						
HEXACHLOROETHANE	R	<W	<W	<W	<W	<W	<W				1.00	19000	
ng/L	T	5	<W	0.45	8.00	<W	1.71						
LINDANE	R	2	<W	0.14	<W	<W	<W				1.00	4000	
ng/L	T	1.00	<W	0.09	2.00	<W	0.29						
METHOXYCHLOR	R	13.00	<W		<W	<W	<W				5.00	100000	
ng/L	T	<W	<W	<W	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
MIREX	R	6.00	<W		<W	<W	<W				5.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
OCTACHLOROSTYRENE	R	11	<W	1.14	<W	<W	<W				1.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
O,P-DDT	R	<W	<W	<W	<W	<W	<W				5.00	30000	
ng/L	T	<W	<W	<W	<W	<W	<W						
OXYCHLORDANE	R	<W	<W	<W	<W	<W	<W				2.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
PCB TOTAL	R	<W	<W	<W	<W	<W	<W				20.00	3000	
ng/L	T	<W	<W	<W	<W	<W	<W						
PENTACHLOROBENZENE	R	8.00	<W	0.57	<W	<W	<W				1.00	74000	
ng/L	T	8.00	<W	1.55	4.00	<W	0.86						
P,P-DDD	R	<W	<W	<W	<W	<W	<W				5.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
P,P-DDE	R	<W	<W	<W	<W	<W	<W				1.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
P,P-DDT	R	<W	<W	<W	<W	<W	<W				5.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
1,2,3,4-TETRACHLOROBENZENE		<W	<W	<W	<W	<W	<W				1.00		
ng/L	T	<W	<W	<W	<W	<W	<W						

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
TRIAZINES	2,4,5-TRICHLOROTOLUENE	R	<W	<W	<W	<W	<W	<W				5.00	10000	
	ng/L	T	<W	<W	<W	14	<W	2						
	2,6,A-TRICHLOROTOLUENE	R	<W	<W	<W	<W	<W	<W				5.00		
	ng/L	T	<W	<W	<W	<W	<W	<W						
	ALACHLOR	R	<W	<W	<W									
	ng/L	T	<W	<W	<W									
	AMETRINE	R	<W	<W	<W	<W						50.00		
	ng/L	T	<W	<W	<W	<W								
	ATRATONE	R	<W	<W	<W									
	ng/L	T	<W	<W	<W									
	ATRAZINE	R	<W	<W	<W	<W						50.00	46000	
	ng/L	T	<W	<W	<W	<W								
	BLADEX	R	<W	<W	<W	<W						100.00	10000	
	ng/L	T	<W	<W	<W	<W								
	METOLACHLOR	R	<W	<W	<W									
	ng/L	T	<W	<W	<W									
	PROMETONE	R	<W	<W	<W	<W						50.00		
	ng/L	T	<W	<W	<W	<W								
	PROMETRYNE	R	<W	<W	<W	<W						50.00	1000	
	ng/L	T	<W	<W	<W	<W								

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
1,2,3,5-TETRACHLOROBENZENE		<W	<W	<W	<W	<W	<W				1.00		
ng/L	T	<W	<W	<W	23.00	<W	3.29						
1,2,4,5-TETRACHLOROBENZEN	R	<W	<W	<W	<W	<W	<W				1.00	38000	
ng/L	T	<W	<W	<W	<W	<W	<W						
THIODAN I	R	<W	<W	<W	<W	<W	<W				2.00	74000	
ng/L	T	<W	<W	<W	<W	<W	<W						
THIODAN II	R	<W	<W	<W	<W	<W	<W				4.00	74000	
ng/L	T	<W	<W	<W	<W	<W	<W						
THIODAN SULPHATE	R	<W	<W	<W	<W	<W	<W				4.00		
ng/L	T	<W	<W	<W	<W	<W	<W						
TOXAPHENE	R				<W	<W	<W						
	T				<W	<W	<W						
1,2,3-TRICHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				5.00	10000	
ng/L	T	<W	<W	<W	<W	<W	<W						
1,2,4-TRICHLOROBENZENE	R	9	<W	0.643	<W	<W	<W				5.00	15000	
ng/L	T	39	<W	5.818	17	<W	4.29						
1,3,5-TRICHLOROBENZENE	R	<W	<W	<W	<W	<W	<W				5.00	10000	
ng/L	T	7.00	<W	0.64	24	<W	4.29						
2,3,6-TRICHLOROTOLUENE	R	7.00	<W	0.50	<W	<W	<W				5.00		
ng/L	T	38.00	<W	3.45	14	<W	3.86						

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
	PROPAZINE	R	<W	<W	<W	<W						50.00		
	ng/L	T	<W	<W	<W	<W								
SPECIAL PESTICIDES	SENCOR	R	<W	<W	<W	<W						100.00		
	ng/L	T	<W	<W	<W	<W								
	SIMAZINE	R	<W	<W	<W	<W						50.00	10000	
	ng/L	T	<W	<W	<W	<W								
	2,4-D	R	NS			<W						100.00	100000	
	ng/L	T	NS			<W								
	2,4-D BUTYRIC ACID	R				<W						200.00	18000	
	ng/L	T				<W								
	DICAMBA	R	NS			<W						100.00	87000	
	ng/L	T	NS			<W								
	PENTACHLOROPHENOL	R	NS			<W						50.00	10000	
	ng/L	T	NS			<W								
	PICLORAM	R	NS			<W						100.00		
	ng/L	T	NS			<W								
	2,4-D PROPIONIC ACID	R	NS			<W						100.00		
	ng/L	T	NS			<W								
	SILVEX	R	NS			<W						50.00	10000	
	ng/L	T	NS			<W								

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
ORGANO-PHOSPHORUS PESTICIDES	2,4,5-T	R	NS			<W						50.00		
	ng/L	T	NS			<W								
	2,3,4,5 T-CHLOROPHENOL	R	NS			<W						50.00		
	ng/L	T	NS			<W								
	2,3,5,6 T-CHLOROPHENOL	R	NS			<W						50.00		
	ng/L	T	NS			<W								
	2,3,4-TRICHLOROPHENOL	R	NS			<W						100.00		
	ng/L	T	NS			<W								
	2,4,5-TRICHLOROPHENOL	R	NS			<W						50.00		
	ng/L	T	NS			<W								
	2,4,6-TRICHLOROPHENOL	R	NS			<W						50.00	10000	
	ng/L	T	NS			<W								
	DIAZINON	R				NS						50.00	14000	
	ng/L	T				NS								
	DICHLOROVOS	R												
	ng/L	T												
	DURSBAN	R												
	ng/L	T												
	ETHION	R												
	ng/L	T												

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
	GUTHION	R												
	ng/L	T												
	MALATHION	R												
	ng/L	T												
	METHYLPARATHION	R										50.00	7000	
	ng/L	T												
	METHYLTRITHION	R												
	ng/L	T												
	MEVINPHOS	R												
	ng/L	T												
	PARATHION	R										50.00	35000	
	ng/L	T												
	PHORBATE	R												
	ng/L	T												
MASS SPEC	RELDAN	R												
	ng/L	T												
	RONNEL	R												
	ng/L	T												
	DI-N-BUTYL PHTHALATE	R	1.20	0.20	0.83	1.10	<W	0.50				0.10	34000	
	ng/L	T	0.80	0.20	0.38	0.70	<W	3.33						

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			
N-DICHLOROMETHYLENE-	R	<W	<W	<W	<W	<W	<W				0.10		
PENTACHLOROANALINE		<W	<W	<W	<W	<W	<W						
DIPHENYL ETHER	R	<W	<W	<W	<W	<W	<W				0.10		
ng/L	T	<W	<W	<W	<W	<W	<W						
FLUORANTHENE	R	<W	<W	<W	<W	<W	<W				0.10		
ng/L	T	<W	<W	<W	<W	<W	<W						
HEXACHLOROPROPENE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									
METHYL PHENANTHRENE	R	<W	<W	<W	0.20	<W	0.07				0.10		
ng/L	T	<W	<W	<W									
NAPHTHALENE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									
PENTACHLOROBUTADIENE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									
PENTACHLOROPROPANE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									
PENTACHLOROPROPENE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									
PYRENE	R	<W	<W	<W							0.10		
ng/L	T	<W	<W	<W									

TABLE 4.0: WATER QUALITY SUMMARY

	PARAMETER		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	OWSP DETECT LIMIT	DRINK WATER GUIDE	AVG.
BACTERIA	TETRACHLORBUTANE	R	<W	<W	<W							0.10		
	ng/L	T	<W	<W	<W									
	TETRACHLOROBIPHENYL	R										0.10		
	ng/L	T												
	RAW WATER:													
	TOTAL COLIFORM MF count/100ml	R	5600	500	2100	5900	600	2100						
	TOTAL COLIFORM BKGD count/100ml	R	12800	670	4731	12300	1000	4033						
	FECAL COLIFORM MF count/100ml	R	600.00	19.00	125.00	178	28	126				0	0/.1 ml	
	STANDARD PLATE COUNT MF count/100ml	R	2400	450	1389	1300	510	893				0	500	
	TREATED WATER:													
	PRESENT/ABSENT TEST	T												

TABLE 4.0: WATER QUALITY SUMMARY

PARAMETER		1986			1985			1984			DWSP DETECT LIMIT	DRINK WATER GUIDE	
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.			AVG.
TOTAL COLIFORM BACKGROUND count/100ml	M	0.00	0.00	0.00	3	0	1				0		
FECAL COLIFORM MF count/100ml	T										0		
STANDARD PLATE COUNT MF count/100ml	T	3	0	1	31	0	8						
COLIFORM P/A	T												
FECAL COLIFORM P/A	T												
E.COLI P/A	T												
AROMONAS P/A	T												
STAPH. AUREUS P/A	T												

NOTES FOR TABLE 4.0 WATER QUALITY SUMMARY

Table 4.0 presents a summary of raw and treated water quality data for physical, microbiological, radiological and chemical parameters. Testing was conducted by the MOE as part of the Drinking Water Surveillance Program on 22 different days in 1985 and 1986.

The following comments should be considered when interpreting the data in this table:

- The testing was not conducted at regular intervals throughout the year.
- Some of the values are based on a very limited number of samples.

TABLE 6.0: BACTERIOLOGICAL TESTING (1984)

		TOTAL COLIFORM				FECAL COLIFORM					FECAL STREP			
		ABS	1-5	6-100	101 5000	ABS	1-5	6 10	11-500	> 500	ABS	1	2-50	> 50
JAN	R													
	T													
FEB	R													
	T		1			1								
MAR	R													
	T													
APR	R													
	T		1			1								
MAY	R				1				1					
	T		1			1								
JUN	R						1							
	T		1			1								
JUL	R													
	T													
AUG	R													
	T		1			1								
SEP	R													
	T													
OCT	R													
	T													
NOV	R													
	T													
DEC	R													
	T		1			1								

TABLE 6.0: BACTERIOLOGICAL TESTING (1985)

		TOTAL COLIFORM				FECAL COLIFORM					FECAL STREP			
		ABS	1-5	6-100	101-5000	ABS	1-5	6-10	11-500	> 500	ABS	1	2-50	> 50
JAN	R													
	T													
FEB	R													
	T													
MAR	R													
	T													
APR	R				1				1					
	T		1			1								
MAY	R													
	T													
JUN	R													
	T		1			1								
JUL	R				1				1					
	T		1			1								
AUG	R				1				1					
	T	1				1								
SEP	R													
	T													
OCT	R													
	T													
NOV	R													
	T													
DEC	R													
	T													

TABLE 6.0: BACTERIOLOGICAL TESTING (1986)

		TOTAL COLIFORM				FECAL COLIFORM					FECAL STREP			
		ABS	1-5	6-100	101-5000	ABS	1-5	6-10	11-500	> 500	ABS	1	2-50	> 50
JAN	R				1				1					
	T	1				1								
FEB	R													
	T													
MAR	R													
	T													
APR	R				1				1					
	T	1				1								
MAY	R													
	T													
JUN	R													
	T													
JUL	R				1				1					
	T	1				1								
AUG	R				2				2					
	T	2				2								
SEP	R													
	T													
OCT	R													
	T													
NOV	R													
	T													
DEC	R													
	T													

TABLE 6.0: BACTERIOLOGICAL TESTING (1987)

		TOTAL COLIFORM				FECAL COLIFORM					FECAL STREP			
		ABS	1-5	6-100	101 5000	ABS	1-5	6 10	11-500	> 500	ABS	1	2-50	> 50
JAN	R													
	T													
FEB	R													
	T													
MAR	R													
	T													
APR	R													
	T													
MAY	R													
	T													
JUN	R													
	T													
JUL	R													
	T													
AUG	R													
	T													
SEP	R				1				1					
	T	1				1								
OCT	R													
	T													
NOV	R													
	T													
DEC	R													
	T													

NOTES FOR TABLE 6.0 BACTERIOLOGICAL TESTING

The bacteriological quality of the treated water is monitored by the Lambton County Health Unit. Sampling is completed by the operator monthly and sent to the Health Unit for analysis.

The table shows the number of samples taken falling into each range of quantity of coliform. All data in the 1-5 range corresponds to a <2 symbol on the Health Unit's report.

According to Ministry of Health guidelines, a total coliform value of <2 and a fecal coliform value of 0 or absent indicates water safe for drinking.

TABLE 7.0 EXCEEDANCE SUMMARY

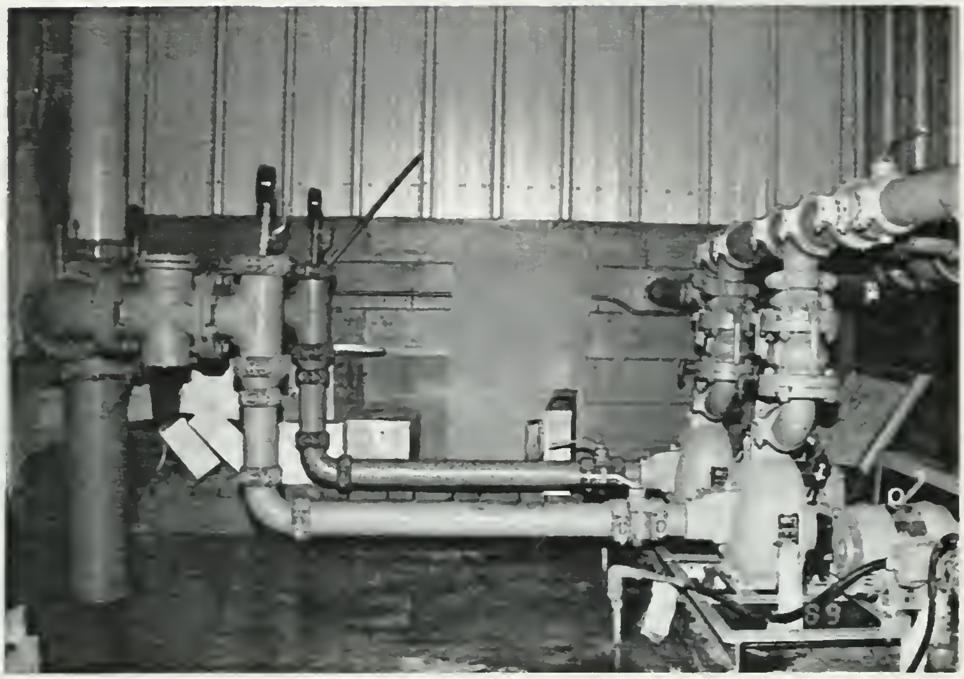
DATE	PARAMETER	MEASURED PARAMETER	OBJECTIVE LIMIT
May 31, 1986	Aluminum	0.11 mg/L	0.1 mg/L
July 16, 1986	Aluminum	0.13 mg/L	0.1 mg/L
Jan. 1, 1984	Turbidity	2.0 FTU	1.0 FTU
Jan. 8, 1984	Turbidity	2.0 FTU	1.0 FTU
Jan. 9, 1984	Turbidity	2.0 FTU	1.0 FTU
March 2, 1985	Turbidity	1.6 FTU	1.0 FTU
March 23, 1985	Turbidity	1.2 FTU	1.0 FTU
March 27, 1985	Turbidity	1.4 FTU	1.0 FTU
May 28, 1985	Turbidity	1.4 FTU	1.0 FTU
July 20, 1985	Turbidity	1.2 FTU	1.0 FTU
Nov. 19, 1985	Turbidity	1.2 FTU	1.0 FTU
Dec. 18, 1985	Turbidity	1.3 FTU	1.0 FTU
Dec. 21, 1985	Turbidity	1.2 FTU	1.0 FTU
Jan. 5, 1986	Turbidity	1.1 FTU	1.0 FTU
Feb. 1, 1986	Turbidity	1.4 FTU	1.0 FTU
Feb. 2, 1986	Turbidity	1.8 FTU	1.0 FTU
Feb. 3, 1986	Turbidity	1.1 FTU	1.0 FTU
Feb. 5, 1986	Turbidity	1.2 FTU	1.0 FTU
Feb. 11, 1986	Turbidity	2.1 FTU	1.0 FTU
March 1, 1986	Turbidity	1.2 FTU	1.0 FTU
March 2, 1986	Turbidity	1.6 FTU	1.0 FTU
March 16, 1986	Turbidity	1.2 FTU	1.0 FTU
March 26, 1986	Turbidity	1.9 FTU	1.0 FTU
May 4, 1986	Turbidity	1.7 FTU	1.0 FTU

NOTE: List health-related parameters which exceed Ontario Drinking Water Objectives.

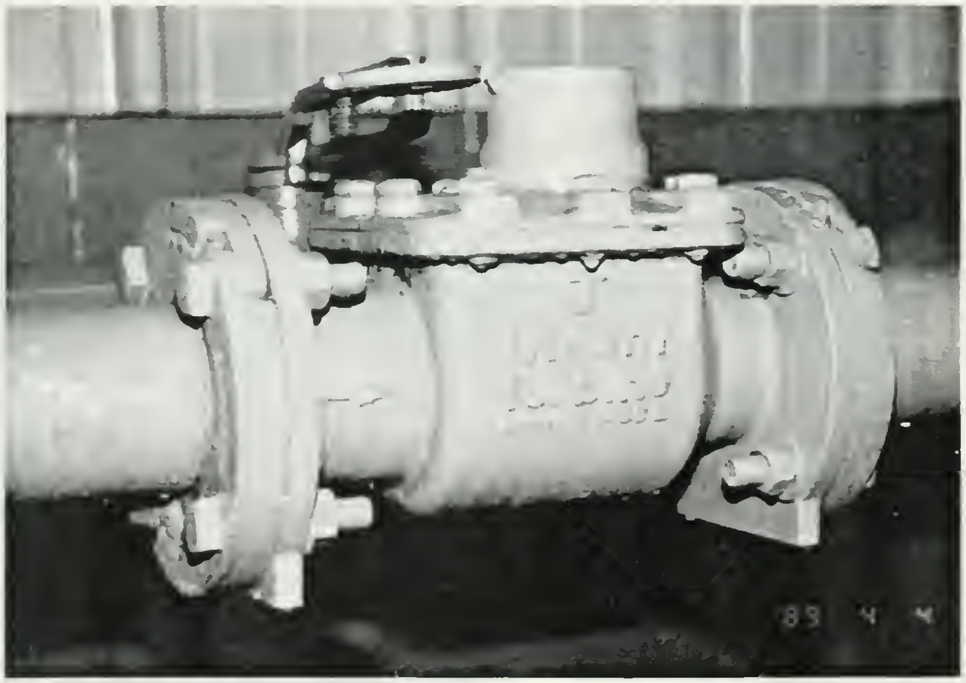
APPENDIX C

SOURCE OF WATER SUPPLY - ST. CLAIR RIVER

TREATMENT PLANT BUILDING

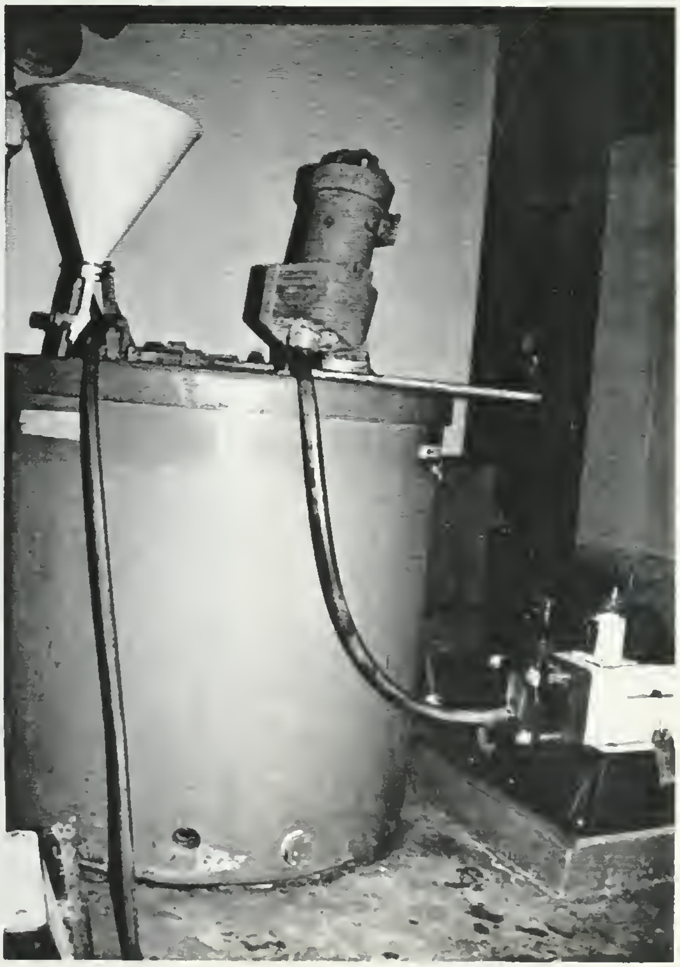


RAW WATER PUMPING EQUIPMENT



RAW WATER METER

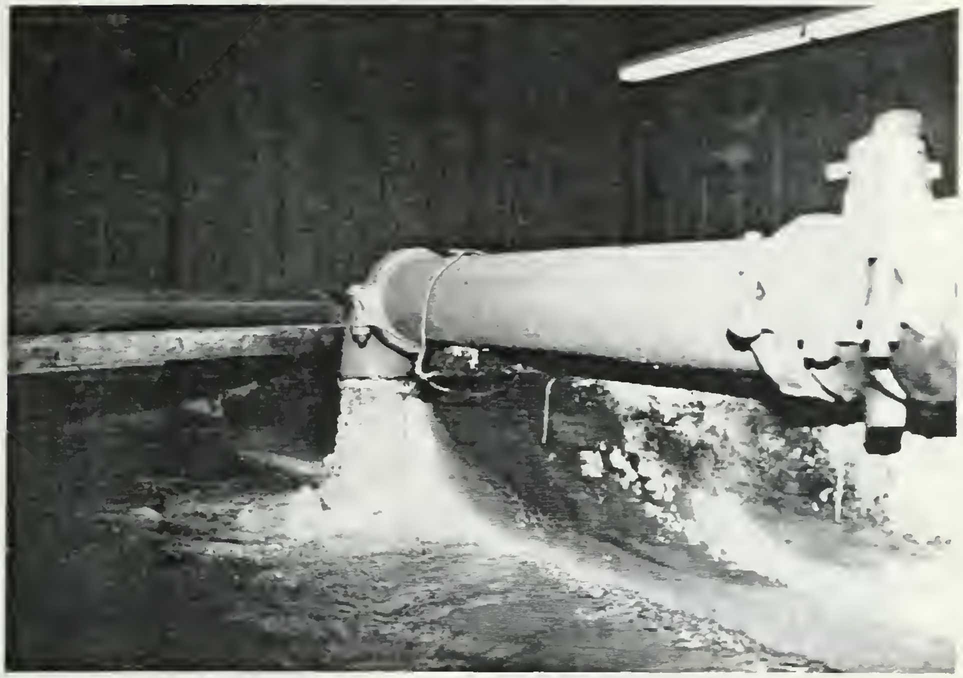
PAC CHEMICAL FEED



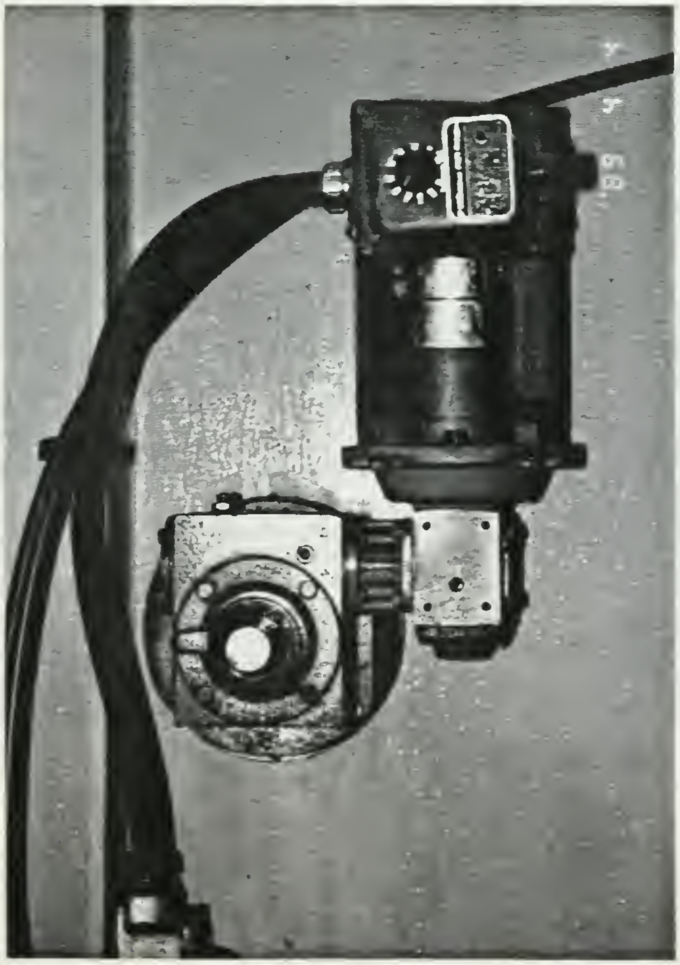
POLYELECTROLYTE
CHEMICAL FEED

ALUMINUM SULPHATE

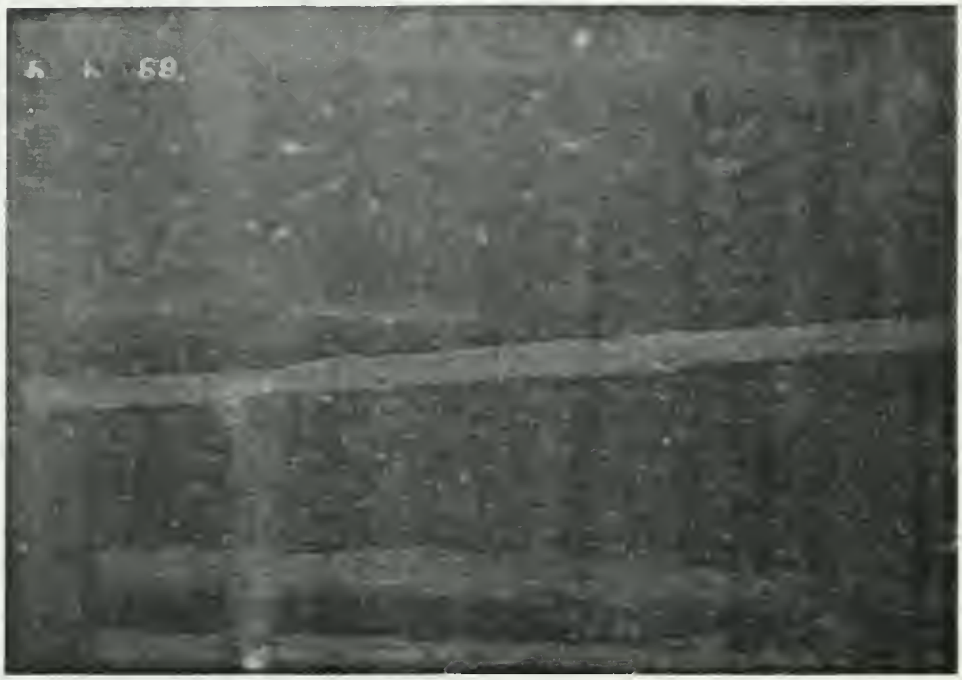
8170 POLYMER



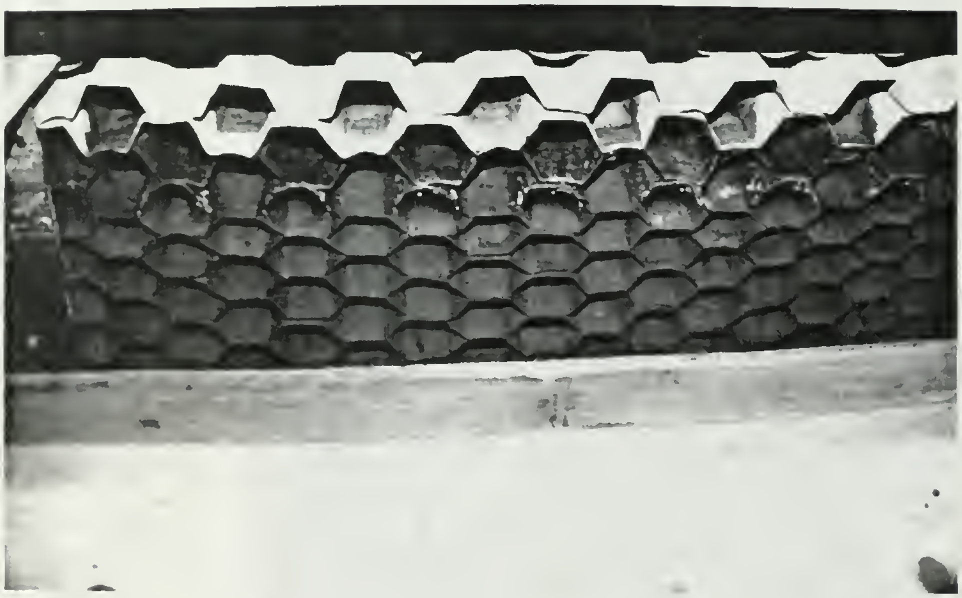
RAW WATER DISCHARGE INTO PACKAGE PLANT



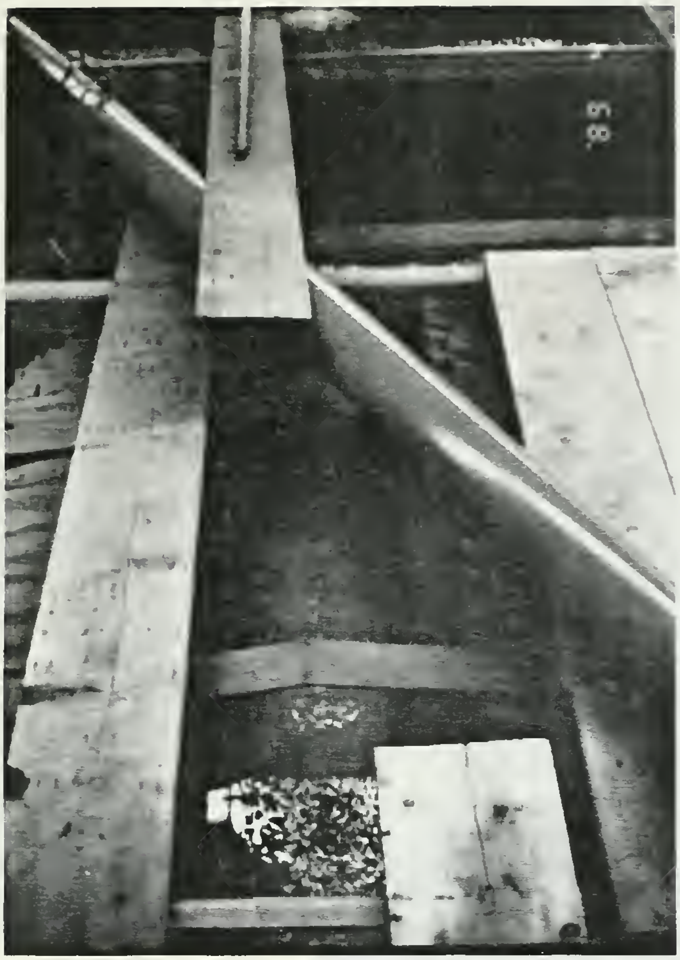
FLOCCULATOR PADDLE
SPEED MOTOR



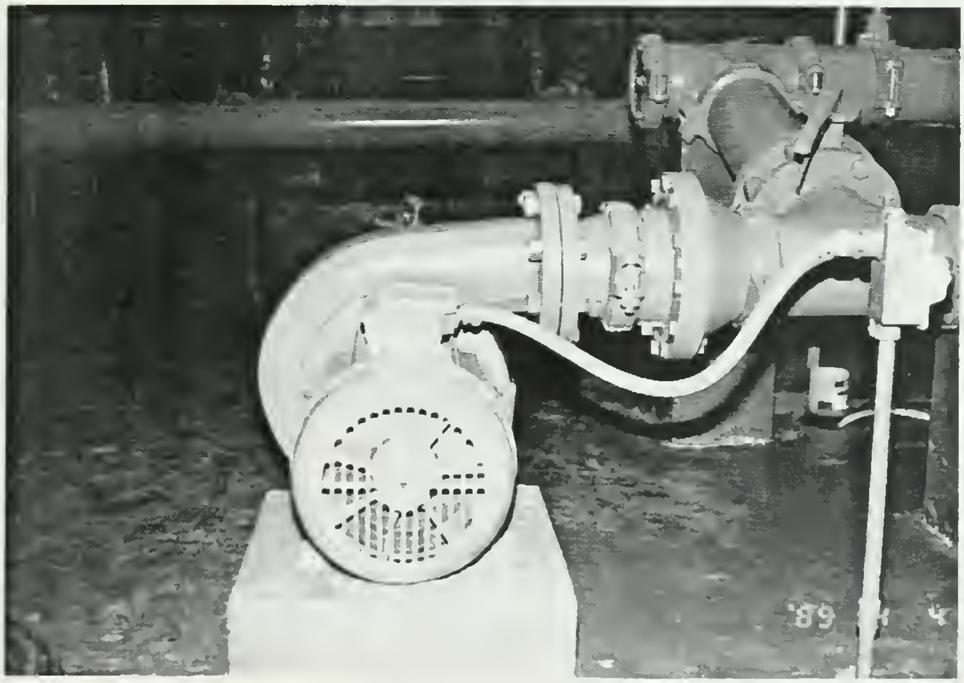
FLOCCULATOR PADDLES



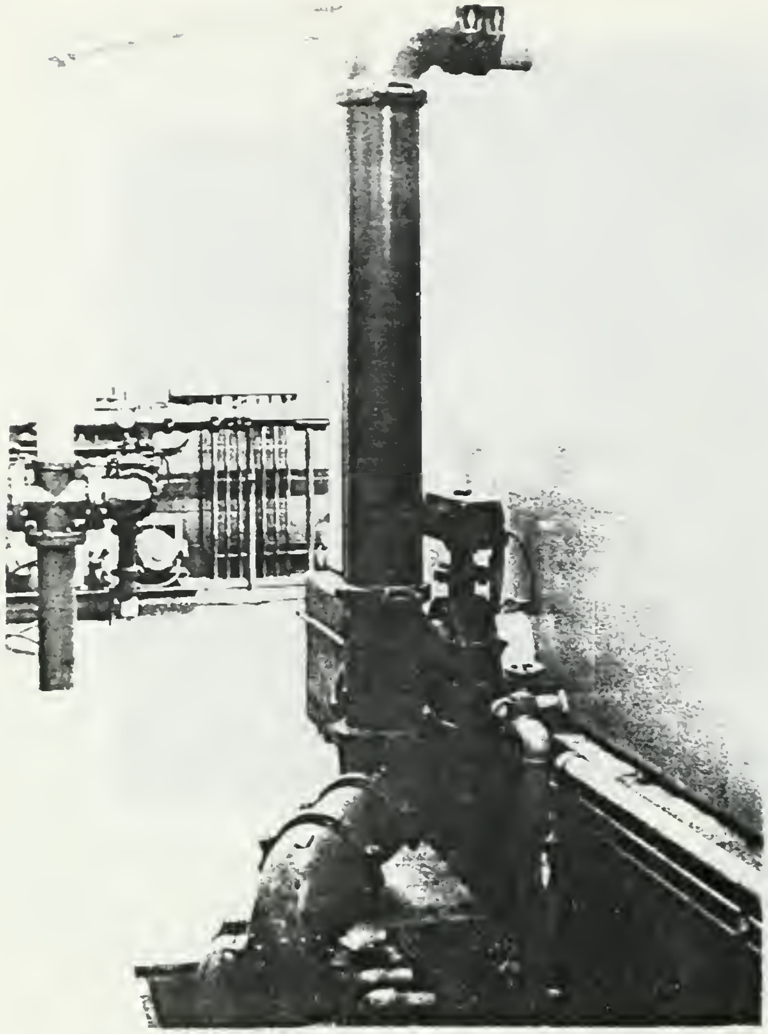
TUBE SETTLERS



FILTRATION ZONE

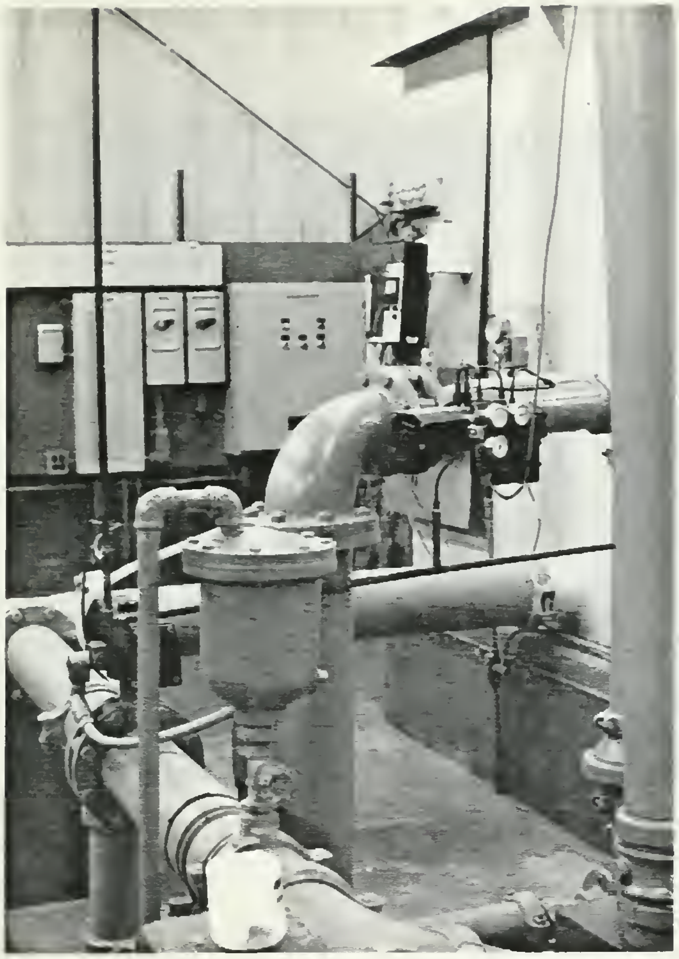


BACKWASH PUMP



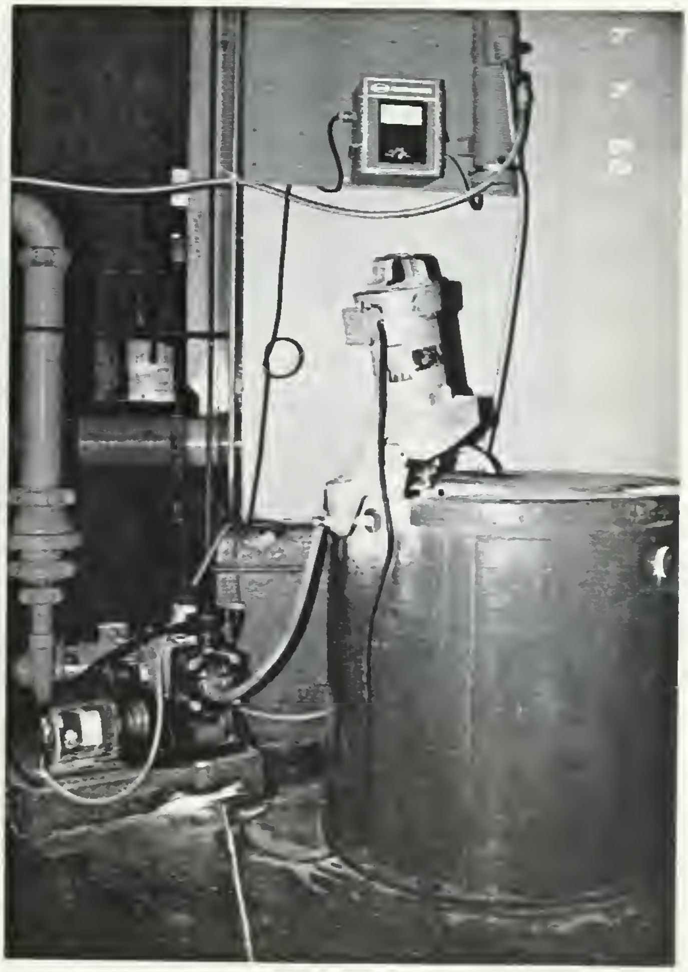
BACKWASH DISCHARGE
LINE

BACKWASH WATER SETTLING TANK

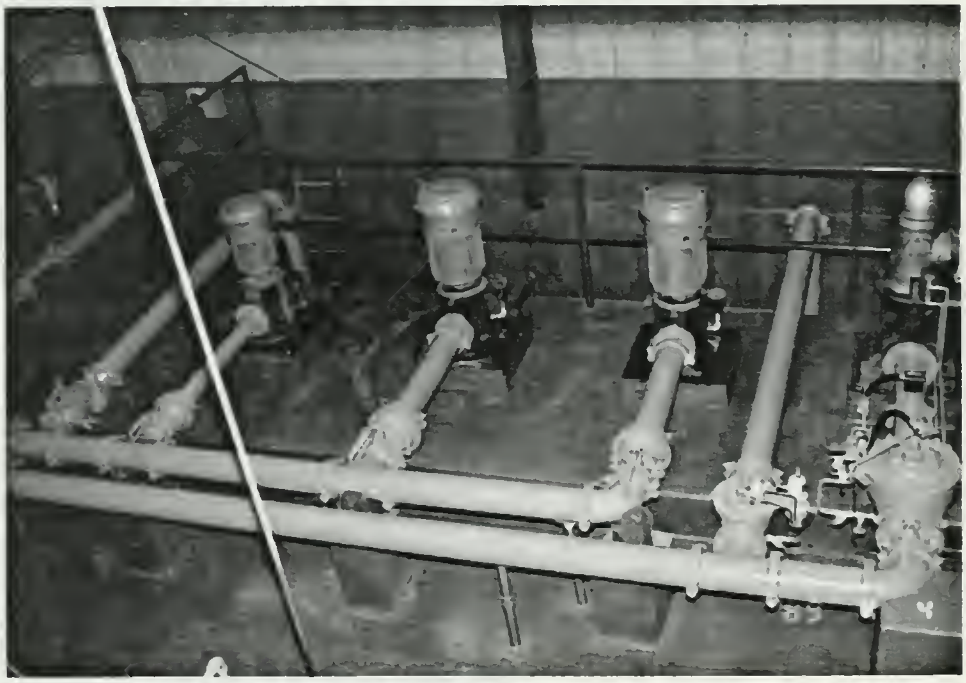


TREATED LINE TO
RESERVOIR

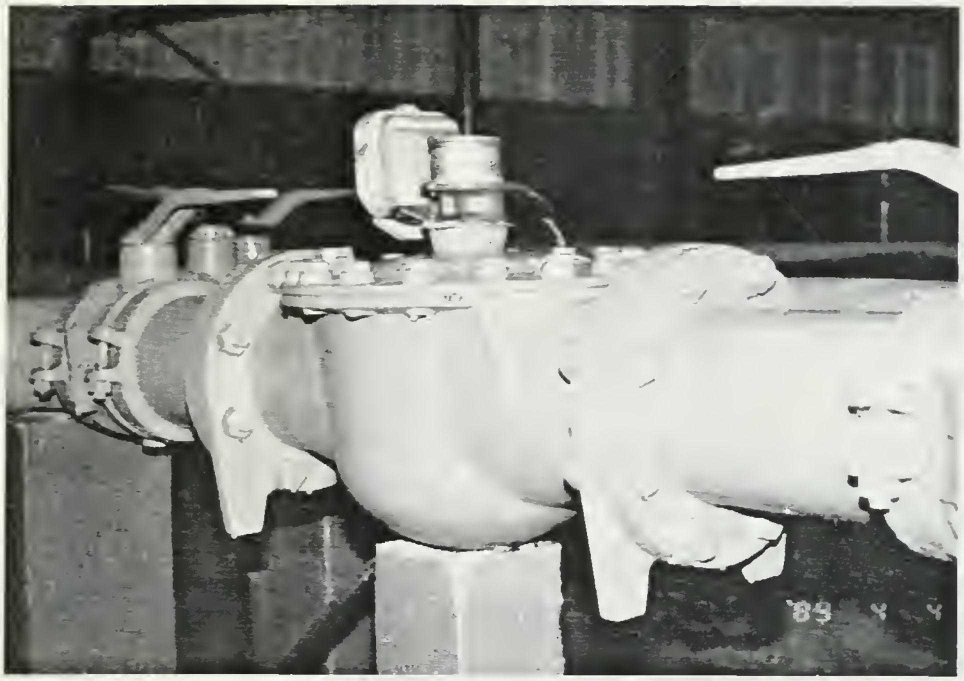
CHLORINE CHEMICAL
FEED



STORAGE RESERVOIR



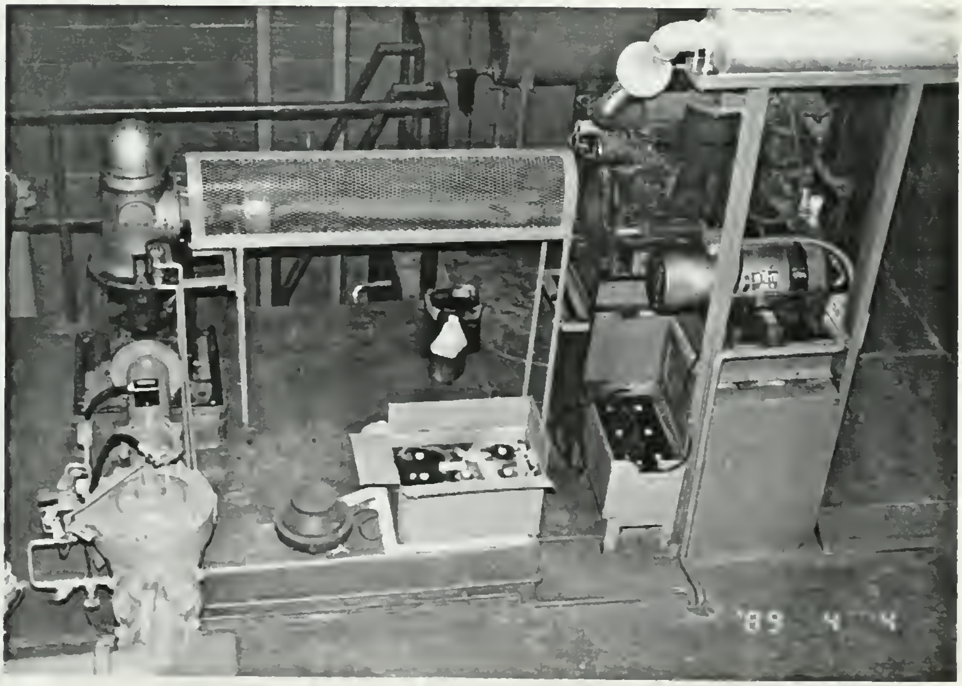
HIGH LIFT PUMPING EQUIPMENT



TREATED WATER METER

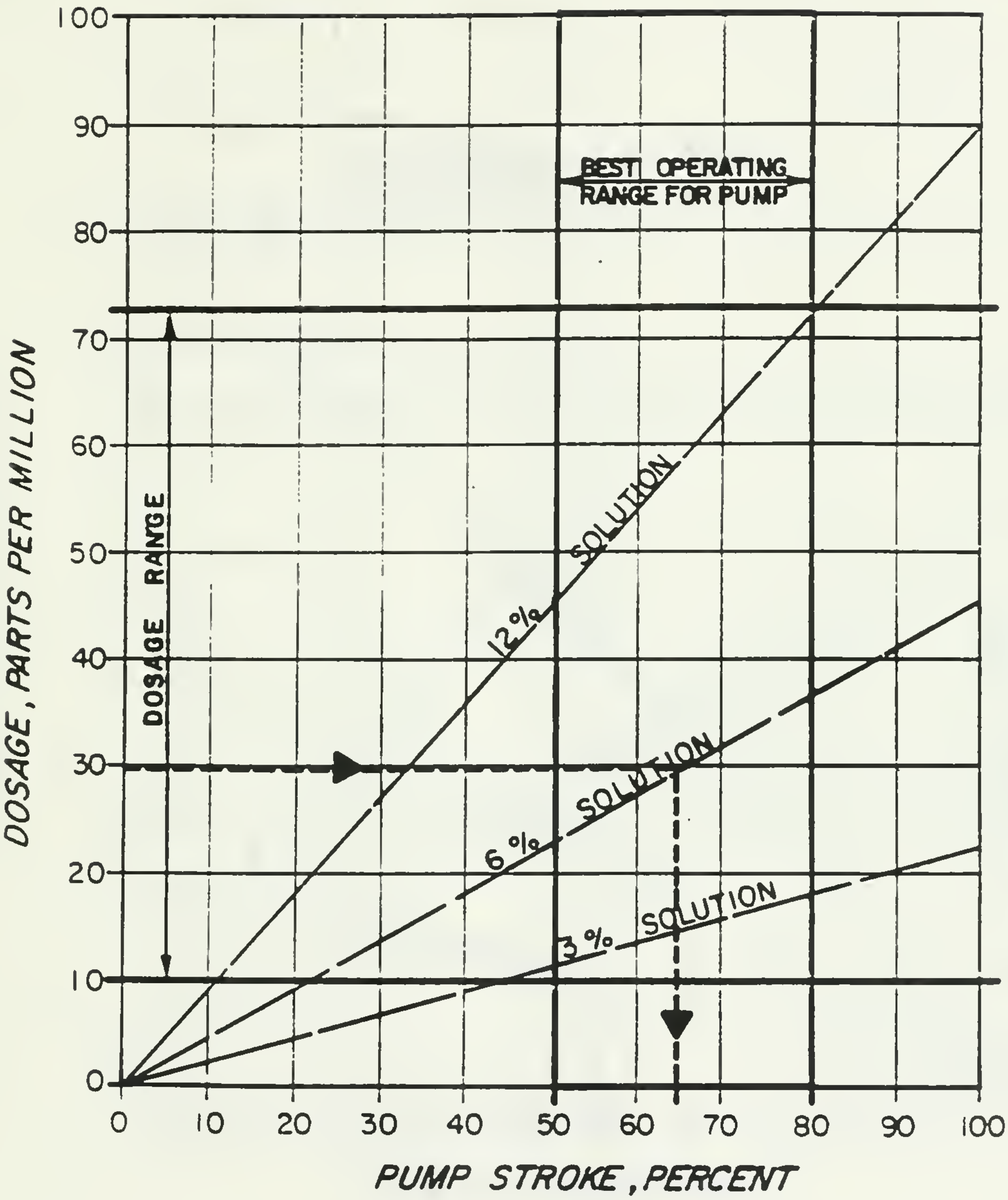
HYDROPNEUMATIC TANK

POST-CHLORINATION
CHEMICAL FEED



DIESEL FIRE PUMP AND GENERATOR

APPENDIX D



ALUM.

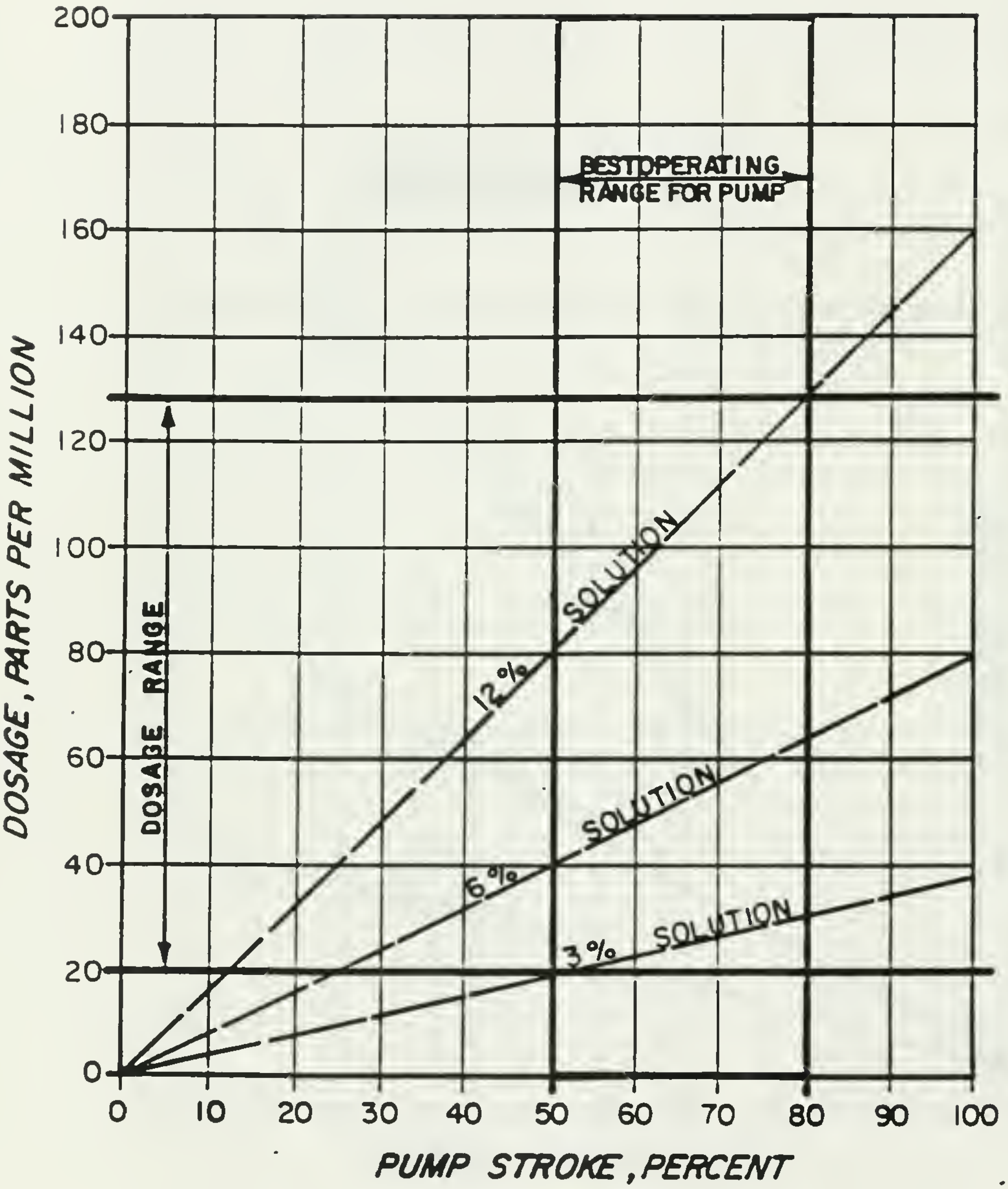
DOSAGE CURVES

PLANT FLOW RATE: 175 U.S. G.P.M.

CHEMICAL FEED PUMP CAPACITY: 190 U.S. G.P.D.

ON SECOND STEP PULLEY

TO FIND PUMP STROKE SETTING FOR A GIVEN P.P.M. DOSAGE — FOLLOW DOSAGE ACROSS TO INTERSECTION WITH SOLUTION STRENGTH IN USE — THEN DOWN TO FIND PUMP STROKE.



ALUM.

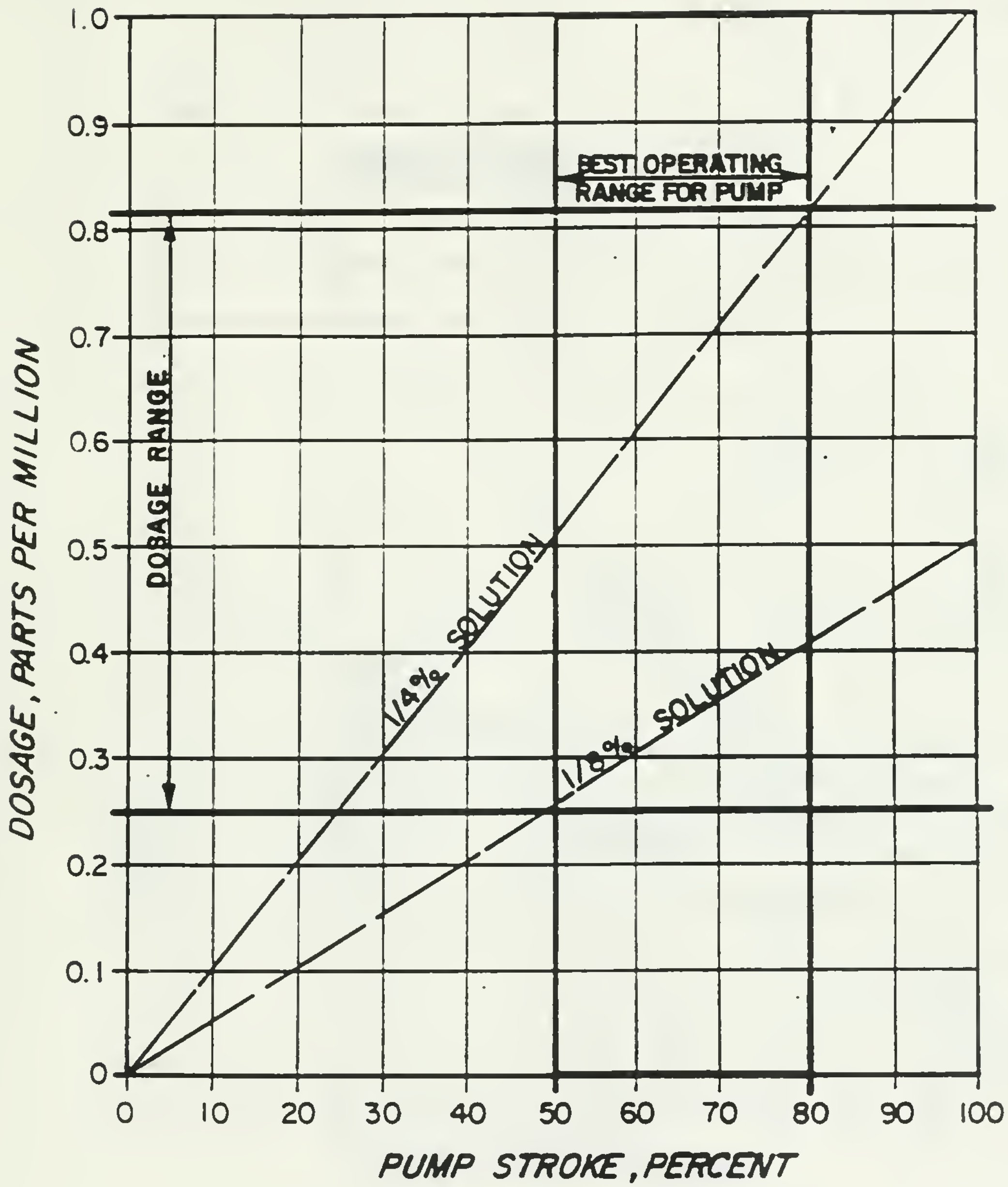
DOSAGE CURVES

PLANT FLOW RATE: 175 U.S. G.P.M.

CHEMICAL FEED PUMP CAPACITY: 330 U.S. G.P.D.

ON THIRD STEP PULLEY

TO FIND PUMP STROKE SETTING FOR A GIVEN P.P.M. DOSAGE— FOLLOW DOSAGE ACROSS TO INTERSECTIO·· WITH SOLUTION STRENGTH IN USE — THEN DOWN TO FIND ·UMP STROKE.



POLYMER

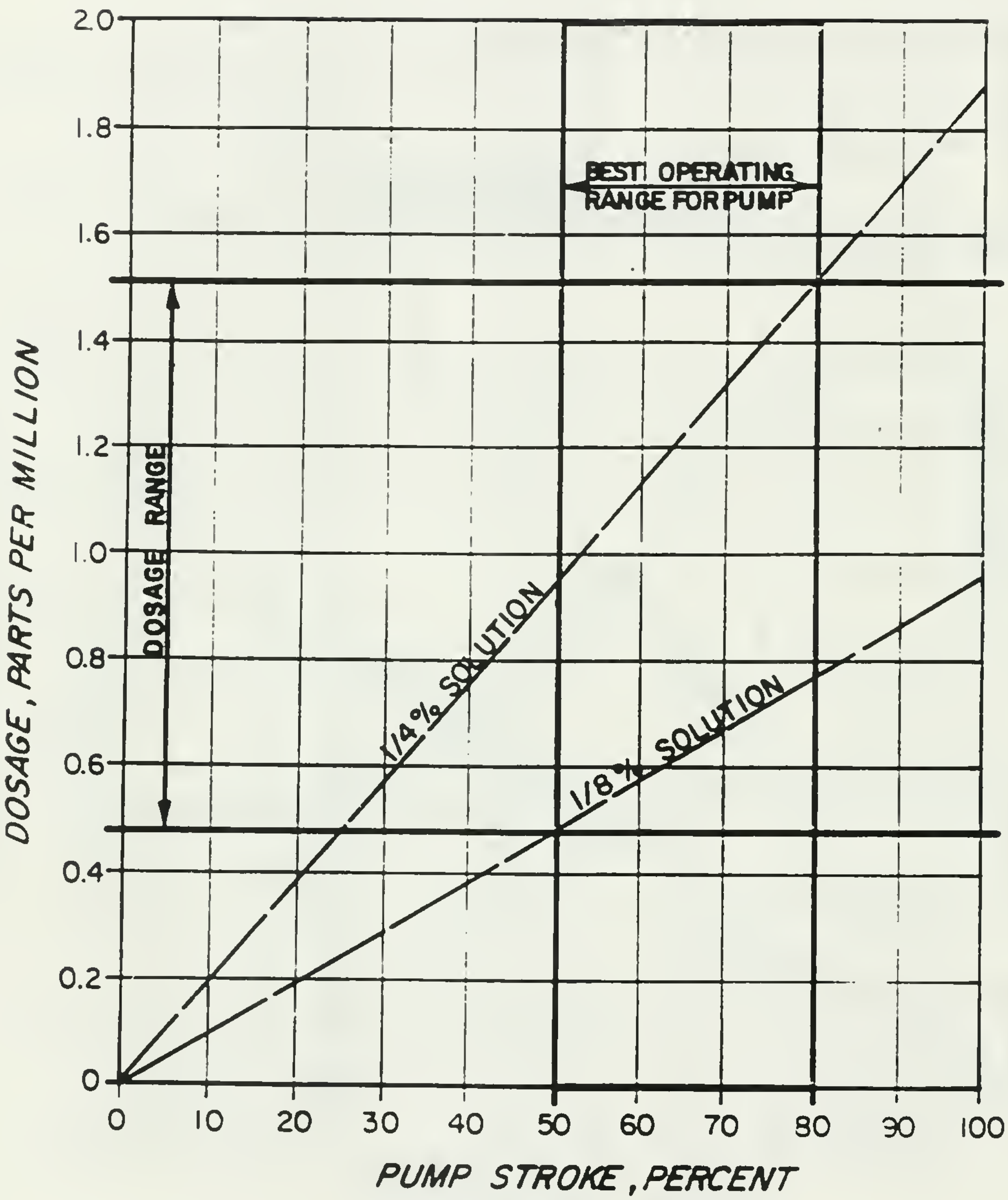
DOSAGE CURVES

PLANT FLOW RATE: 175 U.S. G.P.M.

CHEMICAL FEED PUMP CAPACITY: 110 U.S. G.P.D.

ON FIRST STEP PULLEY

TO FIND PUMP STROKE SETTING FOR A GIVEN P.P.M. DOSAGE – FOLLOW DOSAGE ACROSS TO INTERSECTION WITH SOLUTION STRENGTH IN USE – THEN DOWN TO FIND PUMP STROKE.



POLYMER

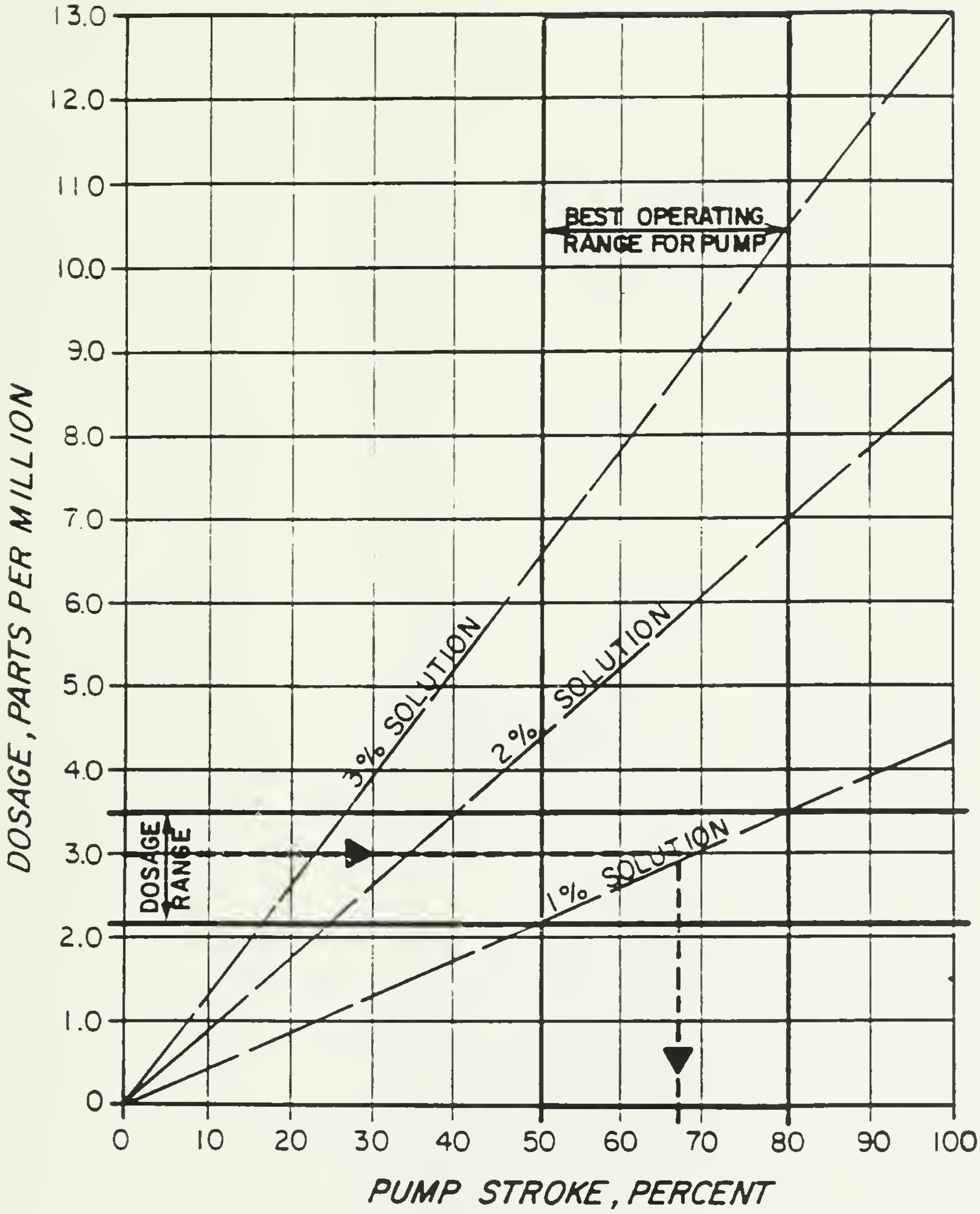
DOSAGE CURVES

PLANT FLOW RATE: 175 U.S. G.P.M.

CHEMICAL FEED PUMP CAPACITY: 190 U.S. G.P.D.

ON SECOND STEP PULLEY

TO FIND PUMP STROKE SETTING FOR A GIVEN P.P.M. DOSAGE—FOLLOW DOSAGE ACROSS TO INTERSECTION WITH SOLUTION STRENGTH IN USE — THEN DOWN TO FIND PUMP STROKE.



PRE. & POST CHLORINATION

DOSAGE CURVES

PLANT FLOW RATE: 175 U.S. G.P.M.

CHEMICAL FEED PUMP CAPACITY: 110 U.S. G.P.D.

ON FIRST STEP PULLEY

TO FIND PUMP STROKE SETTING FOR A GIVEN P.P.M. DOSAGE - FOLLOW DOSAGE ACROSS TO INTERSECTION WITH SOLUTION STRENGTH IN USE — THEN DOWN TO FIND PUMP STROKE

APPENDIX E

JAR TESTS

PURPOSE

Jar tests are used to determine the correct amount of coagulant.

The following chart indicates the advantages of using the proper dosage of alum solution as a coagulant:

	Under Dose	Proper Dose	Over Dose
Turbidity removal	Poor	Good	Fair
Colour removal	Poor	Good	Fair
Algae removal	Poor	Good	Fair
Length of filter runs	Medium	Long	Short
Residual aluminum	High	Low	High
Dollar value	Wasted	Good	Poor

EQUIPMENT REQUIRED (See illustrations on page 13-2)

1. Jar Tester (4 or 6 paddles)
2. Illuminator Box (preferred but not essential)
3. Beakers - 6 (100 or 1500 ml capacity)
4. Pipettes - 5 1-ml graduated (glass)
5. Erlenmeyer Flasks - 6 250-ml capacity
6. Funnels - 6 ribbed, conical 2.5 inch diameter, short stemmed
7. Graduated Cylinders - 2 100-ml (plastic or glass)
   1 1000-ml (plastic or glass)
8. Filter Paper - 11 cm. S&S Black Ribbon 589, or Whatman #41
9. Baster
10. Scale - accurate to 1/20 of a gram
11. Bacteriological sampling bottles - no preservative.

13. After allowing the floc 30 minutes to settle to the bottom, filter the supernatant, using the baster as a sampler, through S & S Black Ribbon #589 filter paper (other coarse filter papers are acceptable).
14. Since many filter papers will give off particular matter early in the filtration, the first 75 - 100 mls of sample should be disregarded.
15. Filter another 100 - 150 mls of sample.
16. Perform turbidity, pH, colour and residual aluminum tests on the filtrate.
17. If you have an iron coagulant or a high iron level in your raw water, carry out an iron test on the filtered water.
18. The hardness test is essential in both a softening and a partial softening plant.
19. The alkalinity test is important in soft waters. It can also be used to check your alum dosage. Remember 1.0 mg/l alum reduces the alkalinity by 0.45 mg/l.
20. The jar that gives the best results using the least amount of coagulant should indicate the proper coagulant dosage for your plant.

Jar Tests Using Coagulants Plus Coagulation Aids

1. To determine if either activated silica or polyelectrolyte can help the coagulation-flocculation-sedimentation process, do the following: Repeat the jar test using the best coagulation dosage as determined from step 20 above (or slightly below this dosage), and add varying amounts of coagulant aid as described at step 5 above for the addition of the coagulant. The amount of activated silica added is usually 10 to 20% of the alum dosage used. Polyelectrolyte dosages rarely exceed 1 mg/l.
2. When determining the use of coagulation aids, keep one jar with alum only. Then compare the results when using only alum to the results obtained when a coagulation aid is added to the alum.

3. When applying jar test results to the plant, it is sometimes found that the plant operates better at a chemical dosage slightly different than that indicated by the jar tests. The jar testing is very efficient both in stirring and settling. If the plant is not as efficient as the jar tests, a higher dosage of coagulant may be needed.

4. The regional or district staff of the Ministry of the Environment should be contacted when difficulties arise either in trying to run the jar tests, or in trying to apply the jar test results to the plant.

Jar Tests Using Coagulants Only

Jar Tests using coagulants only require a 6-place laboratory stirrer or jar tester, as well as six 1500 ml beakers. The procedure for carrying out the test is:

1. Under each stirring paddle, place a 1500 ml beaker
2. Place into each beaker, from a graduated cylinder, exactly 1000 ml of a fresh sample of the raw water.
3. Note on the test sheet the amount of coagulant that you are going to add to each beaker. This amount will vary from beaker to beaker.
4. Start the stirrer and set it at maximum speed (usually 100 + rpm).
5. Add the coagulant in increasing amounts to each successive beaker. For example, 10 mg/l to beaker #1, 20 mg/l to beaker #2, etc.

NOTE: 1 ml of 1% solution in 1000 ml of water is 10 mg/l

6. After the coagulant dosage has been added to the last beaker, continue running the stirrer at maximum speed (100 + rpm) for another minute.
7. Reduce the speed to 30 rpm and allow the stirring to continue for 30 minutes.
8. Note how long it takes before a floc begins to form
9. Note how well it withstands some stirring without breaking up.
10. Stop the stirrer after 30 minutes. Note how long it takes for the floc to settle to the bottom of the beaker.
11. After allowing the floc to settle for 20 minutes, note the colour and the turbidity of the supernatant (the liquid above the floc). This sample is obtained by using a baster.
12. Remember to note your chemical dosages, mixing time and speed, pH, floc growth characteristics and supernatant analysis on your operating sheets.

JAR TESTING RESULTS

PLACE: Walpole Island Water Treatment Plant
JOB NO: C-985
DATE: APRIL 4/89
RUN NO: 1

RAW WATER TURBIDITY 4.2
TEMPERATURE 8 DEG C

MIXING SPEED 1 minutes @ 100+ rpm
15 minutes @ 30 rpm
SETTLING TIME 30 minutes

JAR #	CHEMICAL Alum solution mg/L	ml	%	CHEMICAL solution mg/L	ml	%	FLOC FORMATION Description	Time min	SETTLING Description	Time min	SUPERNATANT TURBIDITY
1	2		0.2				no significant formation				2.5
2	6		0.6				pin floc				2.1
3	10		1.0				pin floc				2.1
4	14		1.4				light formation		floating to top		1.1
5	18		1.8				substantial formation		floating to top		0.5
6	22		2.2				substantial formation		floating to top		1.1

COMMENTS:

Assume optimum ~ 18 mg/L

JAR TESTING RESULTS

PLACE: Walpole Island Water Treatment Plant
JOB NO: C-985
DATE: APRIL 4/89
RUN NO: 2

RAW WATER			MIXING SPEED	
TURBIDITY	2.6		MIXING SPEED	1 minutes @ 100+ rpm
pH	7.6			30 minutes @ 30 rpm
TEMPERATURE	8.0 DEG C		SETTLING TIME	30 minutes

JAR #	CHEMICAL Alum solution 1.0 % mg/L	ml	CHEMICAL solution mg/L	% ml	FLOC FORMATION Description	Time min	SETTLING Description	Time min	SUPERNATANT TURBIDITY
1	5	0.5			very light formation			10	2.5
2	15	1.5			light formation	15		10	1.0
3	25	2.5			medium formation	10		8	0.4
4	35	3.5			substantial formation	5		7	0.3
5	45	4.5			light formation	15		10	0.2
6	55	5.5			light formation	15		10	0.6

COMMENTS:

No significant improvement for > 25 mg/L
In view of results for Run # 1 - (18 mg/L)
choose 20 mg/L for constant alum dosage.

JAR TESTING RESULTS

PLACE: Walpole Island Water Treatment Plant
JOB NO: C-985
DATE: APRIL 4/89
RUN NO: 3

RAW WATER	TURBIDITY	3.8 (3.0)	MIXING SPEED	1 minutes @	100+ rpm
	pH	7.6		30 minutes @	30 rpm
	TEMPERATURE	8.0 DEG C	SETTLING TIME	30 minutes	

JAR #	CHEMICAL Alum solution 1.0 % mg/L	ml	CHEMICAL Polyelec solution 1/8 % mg/L	ml	FLOC FORMATION Description	Time min	SETTLING Description	Time min	SUPERNATANT TURBIDITY	CORRECTED TURBIDITY
1	20	2.0	0.05	0.04	light formation	10	not much settling	10	1.7	0.9
2	20	2.0	0.10	0.08	medium formation	5	not much settling	10	1.4	0.6
3	20	2.0	0.20	0.16	heavy formation	2	clumping at bottom	2	0.9	0.1
4	20	2.0	0.25	0.20	heavy formation	3	clumping at bottom	2	1.3	0.5
5	20	2.0	0.30	0.24	medium formation	5	clumping fairly clear	2	1.3	0.5
6	20	2.0	0.35	0.28	medium formation	10	clumping at bottom	2	1.1	0.3

COMMENTS:

Glassware for reading turbidity was not cleaned between readings
A quick calibration was completed after jar testing giving the following results

	Turbidity
Glassware after use	0.9
Clean Glassware	0.1

The last column corrects for this error

APPENDIX F

WALPOLE ISLAND INDIAN RESERVE N°46

WATER SUPPLY SYSTEM RECORDS - MONTH ______ YEAR ______

DATE	TIME	RAW WATER: RAW WATER QUALITY	RAW WATER METER READING	QUANTITY PUMPED	PLANT SUPPLY RATE	CHEMICAL FEED (1) ALUM: AM'T ADDED LBS/GALS	ALUM: % SOL'N	ALUM: FEED RATE mg/L	POLY: AM'T ADDED LBS/GALS	POLY: % SOL'N	POLY: FEED RATE mg/L	CHLORINE: AM'T ADDED LBS/GALS	CHLORINE: % SOL'N	CHLORINE: FEED RATE mg/L	TREATED WATER: TURBIDITY	RESIDUAL CHLORINE	POST CHLORINE CHEMICAL FEED (2): AM'T ADDED LBS/GALS	POST CHLORINE: % SOL'N	POST CHLORINE: FEED RATE mg/L	CHLORINE RESIDUAL: LOCATION	CHLORINE RESIDUAL: RESULTS	BACTERIOLOGICAL TESTS: LOCATION	BACTERIOLOGICAL TESTS: RESULTS	PUMPS: SYSTEM PRESSURE	HIGH LIFT PUMPS STARTS / HR	PUMP OPERATION (1)	DIESEL TEST RUN: ON PRESS	ON PF	ON MAN	DIESEL: HR METER READING	TREATED WATER METER READING	QUANTITY PUMPED	RAW WATER QTY LESS TREATED WATER QTY	REMARKS	OPER INIT
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MONTHLY SUMMARY

TOTAL QUANTITY OF RAW WATER TREATED			TOTAL HOURS OF PUMP OPERATION			TOTAL DIESEL FUEL USED	
TOTAL QUANTITY OF TREATED WATER PUMPED TO SYSTEM			RAW WATER PUMPS	N°1		TOTAL FURNACE OIL USED	
				N°2			
AVERAGE AMOUNT OF TREATED WATER USED PER DAY			FILTER BACKWASH PUMP				
MAX QUANTITY OF WATER USED IN ONE DAY	RAW WATER		BACKWASH DISCHARGE PUMP				
	TREATED WATER		EFFLUENT PUMP				
AMOUNT OF CHEMICALS USED	ALUM		HIGH LIFT PUMPS	N°1			
	POLY			N°2			
	PRE CL			N°3			
	POST CL			DIESEL			

ADDITIONAL REMARKS OR OBSERVATIONS

NOTES

1. NOTE IF CHEMICAL FEED PUMP NOT IN USE
2. NOTE IF ANY PUMP OPERATION IS ABNORMAL

ABBREVIATIONS

AM'T	AMOUNT	PF	POWER FAILURE
GALS	GALLONS	HR	HOUR
LBS	POUNDS	MAN	MANUAL
mg/L	MILLIGRAMS PER LITRE	PRESS	PRESSURE
SOL'N	SOLUTION	CL	CHLORINE
QTY	QUANTITY	POLY	POLYMER
MAX	MAXIMUM	OPER	OPERATOR
		INIT	INITIAL

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